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SURVEY OF RECENT PROGRESS MADE IN ZOOLOGY.

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Zoology has far outgrown its original boundaries when it could be defined simply as a part of natural history, and at no period has its growth been more rapid than during the last twenty-five years. It is impossible, however, even if time permitted, for any one observer to survey its many lines of activity in this fruitful period. I shall, therefore, not lay claim to any thorough or adequate survey as implied by this title, but rather endeavor to point out some of the more salient features as seen by a prejudiced observer.

There are three distinct periods in the development of Zoology which may be briefly denoted as the descriptive, the historical, and the experimental. Each of these periods may be characterized by definite aspects or methods of study. Thus the first period was concerned chiefly with descriptive and comparative morphology, in an attempt to determine the existing order of the facts of nature. The second period was characterized by phylogenetic considerations, or an historical development of its evolutionary aspects, in an attempt to explain the existing order—the present by reference to the past. The third period is concerned with experimental and analytical methods in an endeavor to explain the facts by varying the conditions under which they take place.

The last-mentioned period is the modern zoology of the last twenty-five years. It is a period of unprecedented progress, whose renaissance has its chief creative impulse in the consciousness of evolution. This revelation of modern science, which we all acknowledge as our

guiding star, has come to mean world growth. It is the base line from which we all work and towards which we all aspire.

For the eventual solution of this broadcast of all biological problems we have attempted to attack it from two different points of vantage. Zoologists, therefore, are divided into two groups—those who would attempt to explain the organism by the substance or elements of which it is composed, and those who would explain the substance or elements by the organism as a whole. These two aspects of the science of Zoology run as the main general pathways guiding the course of the more detailed and intensive researches in the field. The latter point of view had its origin in the earlier Natural History. Older zoologists were concerned with the organism as a whole, its activities, habits, responses, and the role played in the economy of nature. It is to this field of research that we are indebted directly for the formulation of the principle of evolution. Natural history and its resultant theory of evolution took definite shape long before the ultimate structure of living bodies was in any degree comprehended.

The former point of view has as its keynote the cell principle which arose from the study of microscopic anatomy. It was begun and long carried forward with no thought of its bearing on the origin of living forms. Only within the last twenty-five years have the elemental conception and the organismal conception been able to form a close alliance on the common ground of the principle of evolution. This became possible through the formulation of the great problems of development and heredity in terms of the cell. One of the most striking evidences of the progress that modern biology has shown is the fact that these two great lines of research, both concerned with the deeper problems of life, yet having their beginnings so far apart, have at length converged to a meeting point.

While natural history has systematically set forth the results and the method of organic evolution, the cell principle has shown us the nature of the material on which it has operated, demonstrating that the obvious characters of the organism are but varying expressions

of a more subtle interior organization common to all. The cell theory in its present form has been a turning point in the advance of Zoology, opening a new point of view for the study of organisms which has continued to press forward into ever expanding fields of discovery. It has opened up far-reaching vistas of progress in physiology by revolutionizing our views of vital action. It has been shown to be the central phenomenon in organic reproduction, development, and genetic continuity. In the hands of Boveri and his successors it provided the basis for the analysis of heredity, the most remarkable achievement of modern Zoology.

Researches in this field fall into three periods: The first, from 1840 to 1870, was a time of foundation during which the fundamental outlines of the theory were marked out and the principle of genetic continuity became more clearly defined. The second, 1870 to 1900, included the development of cytology and cellular embryology which gave more definite form to our general ideas concerning the physical basis of heredity and the mechanism of development. The third period, opening with the rediscovery of Mendel's laws in 1900, includes those modern and more searching inquiries into the mechanism of sex and heredity which find their fullest expression in the so-called chromosome theory of heredity.

Both structurally and physiologically, the multicellular organism suggests an aggregate or colony of unicellular ones. Whether this be literally true or not, the analysis of biological phenomena is made definite and effective by the conception that the cell constitutes a primary organic unit both of structure and of function. We now can see through the study of the organism as a whole that this statement requires some qualifications, especially as applied to the phenomena of growth and differentiation, but the conviction of its essential truth has survived all criticism. Measured by its fruitfulness it stands among the most important generalizations of modern Zoology.

The influence of the cell principle on embryological research has been especially fruitful. Where in the earlier years it was purely morphological in nature it has

now become predominatingly experimental. Prior to the cell theory, all attempts to comprehend the mechanism of development had been futile. Following it, the morphology of development was rapidly comprehended in its more essential aspects, and the zoologists of today are busy interpreting the *why* of its various aspects.

In the interpretation of the mechanics of mitosis the old superficial fibrillar and reticular theories of Klein, VanBeneden, and Heidenhain, have given way to dynamic interpretations that seems well on the way to a solution of the problem. This was made possible through the biochemical interpretation of protoplasm as a colloidal state and the introduction of experimental methods. In the forefront of these interpretations stand R. S. Lillie's hypothesis concerning the role of electrical phenomena which offers many important suggestions for further inquiry. Lillie demonstrated that a marked difference in potentials existed between chromatin and the cytoplasm, and from this starting point he was able to artificially imitate many of the phenomena of mitosis. Although he was not able to explain adequately the movement of chromatin towards the poles, or convincingly explain the achromatic figure by the polarization of colloidal particles, the analogy which he has drawn may have a substantial basis.

Of especial interest in this connection are the earlier experiments on surface tension in oil drops which have been strikingly confirmed by the more recent work of Spek, who described vortical currents in the division of the living egg. McClendon and Spek have demonstrated that the actual division of the cytoplasm may be imitated in artificial models by varying the surface tension. So striking is the analogy between the oil drops and actual cell division that the correctness of the conclusion can hardly be doubted, and if they are further substantiated, important progress will have been made towards a comprehension of cleavage.

Almost coincidently Chambers and Heilbrun by microdissection and centrifuging methods have demonstrated changes of protoplasmic viscosity during mitosis that shed further light and confirmation on these phenomena of mitosis. These various observations constitute an im-

portant advance in our knowledge of the mechanism of mitosis, though they have not yet been brought into definite relation with each other.

The nature of the division of chromosomes and the doubling of the spireme thread at present remains a pure speculation. The questions raised belong to the problems of growth and self-perpetuation and have yet found no adequate biochemical answer.

Growth and cell division constitute the central phenomenon in every process of reproduction. Upon them depends the genetic continuity of living organisms. The question has been raised as to whether these two processes are really fundamental. It is obvious that the conditions on which the life cycle depends are partly internal to the cell and partly external. Every individual displays a succession of youth, maturity, old age, and death as progressive phases of a process that goes forward from the moment that life begins. To a certain extent the course of the process can be experimentally modified, but sooner or later the end is inevitable. We are not yet certain that sexuality is a fundamental part of this cycle in all living matter. Nevertheless, it seems to be an all but universal phenomenon. Recent researches have shown that the relation between sexual reproduction and parthenogenesis as they occur in nature are widely varied, running the whole gamut from animals, where there is only a sexual cycle, through those forms where the sexual and asexual alternate with each other, to those in which a sex process is unknown, reproduction being purely parthenogenetic. Such facts have clearly demonstrated that sexuality may readily become much restricted or wholly dispensed with, and hence cannot be regarded as a fundamental necessity of continued life.

The culture of tissues outside the body has been a fruitful field of research that has yielded many interesting results. Carrol and Ebeling obtained fibroblasts from the heart of a chick embryo which have been kept growing for more than ten years with undiminished vitality and without change of type. Many others have contributed in this field, among whom should be mentioned the Lewises and Harrison. In the case of Carrol's ex-

periments, more than thirty thousand cultures have been obtained from the original fragment, and the cells have passed through more than two thousand generations. Had it been possible to preserve all the cells thus produced, their combined volume would be greater than that of the sun. This result impresses us with the limitless power of increase of living matter by growth and division, and that cells seem to undergo no decrease in vitality in the complete absence of syngamy.

Yet in spite of these facts, senescence remains the most common and saddest observation that we make on every hand. Its cause has therefore been a prolific field of speculation and investigation. Weisman originally contended that senescence, though real, is not the result of an inherent property in protoplasm, but is due to a secondary cause. This secondary cause, he claimed, was due to progressive differentiation by which the cells gradually lost their plasticity. Many other theories have been proposed, most prominent among which stands out the work of Childs, who refers senescence to a decrease in the rate of metabolism. This conclusion which in substance is closely akin to that of Weisman is perhaps the best founded, but even here the bottom of the problem has not yet been reached. Tissue cultures have shown that even differentiated cells live long beyond the normal span of life. Considerable weight must therefore be given Pearl's conclusions that the senescence of higher organisms is due to a disturbance in the complex balance that exists between mutually dependent cells, of which they are built up.

Recent investigations on protozoa have shed some light on the subject. While rejuvenescence as a consequence of fertilization is an obvious fact in higher plants and animals, such is not necessarily the case in protozoa. Weisman contended that unicellular organisms are capable of indefinite continued growth and division, but later studies revealed many complicating factors which have raised fresh doubts concerning the validity of this contention. The work of Calkins on *Paramoecium* and *Uroleptus* has shown that the life of these species runs in cycles, periods of activity being followed by periods of depression, which in turn are followed by death, if

conjugation does not take place. But the duration and the character of the life cycle was found to be markedly influenced by external factors. These external factors in their effect establish a close analogy between it and artificial parthenogenesis in the animal egg.

The experiments of Woodruff on *Paramoecium* have likewise demonstrated that when cultured in infusions of various organic materials, they may be kept in a flourishing condition without periods of depression and without conjugation almost indefinitely. Cytological studies made by Woodruff proved that a process of reconstruction of the nuclear material took place periodically and resulted in continued rejuvenescence. To this process he gave the name of endomyxis. It is now probable that endomyxis and conjugation play the same role physiologically.

From these facts it becomes apparent that the original theory of a universal tendency to senescence and death on the part of all living organisms can no longer be maintained. Many forms of protoplasm are capable of indefinitely continued life.

The germ cells have offered to the student of development and heredity perhaps the widest range of problems of fundamental importance, and they constitute the major bulk of recent zoological literature. In the limited time at my disposal I can only touch upon some of the more salient features.

Fertilization comprises two closely associated, but experimentally separable events. One of these, primarily of interest from a physiological point of view, is the activation of the egg by the sperm. The second, of special importance for the study of cytology and genetics, is a union or association of corresponding maternal and paternal elements which results in biparental heredity. Both these results are brought about by a union and fusion of two germ cells or gametes to form a single cell, the zygote—a process which finds its prototype in the conjugation of unicellular organisms.

In the light of recent research, it is now established that the sperm carries into the egg all of the components that have entered into its formation, and not only the head or nucleus as was formerly maintained. The older

conception that the sperm was attracted to the egg by a chemotactic action has been called into question by the more recent experiments of Buller, Yatsu, Morgan, and Dewitz, which show that the sperm comes into contact with the egg envelope by mere accident. Likewise the entrance of the sperm into the egg, which was formerly supposed to take place by the boring action of the acrosome (formerly called the perforatorium for this reason) has been shown to be due to some physical action set up within the egg which causes the sperm to be drawn passively into it. It has been suggested by Bowen that the acrosome may be the bearer of some substance that plays a part in the activation of the egg.

Attempts to explain the nature of fertilization constitute some of the major researches of recent Zoology. The problem itself has two aspects, each of which has been represented by two quite independent groups of experimenters. The first group have concerned themselves with the question as to how the egg and spermatozoon produce a cell capable of division, while the second group have concerned themselves with the question as to how these cells came to be capable of reproducing the qualities of the parent in the offspring. This last mentioned group as a result established the chromosome theory of heredity. Strictly speaking, the two phases of this problem overlap, but nevertheless, only a part of the chromosome theory is involved in the problem of fertilization, for it includes the entire life-history and the succession of generations.

Boveri suggested the first comprehensive theory of fertilization which was to the effect that the egg possessed all the organs and qualities necessary for division, except the centrosome, by which division is initiated. The spermatozoon, on the other hand, is provided with a centrosome, but lacks the substance in which this organ may exert its activity. Through the union of the two cells in fertilization, all the essential organs necessary for division are brought together. This theory formed the center of a long controversy. According to it the centrosome of the sperm must be the primary cleavage centrosome of the egg. Definite proof of this continuity is conspicuously lacking in the dozens of papers on the

subject. Moreover, Lillie has shown by centrifuging the eggs of *Nereis*, that it is possible to remove the centrosome from the entering sperm. In such cases the primary cleavage center is nevertheless developed in the egg. It has also been demonstrated by a number of observers that such centrosomes may arise *de novo*. For these and a number of other reasons, the theory has been called into question. Boveri's theory accounted for activation only, and did not take into account the problem of the union of gametes or of the specificity in their behavior.

Studies in experimental parthenogenesis have led us to suspect that some common factor might be found in these two methods of activation. Loeb, therefore, developed a theory of cytolysis in an attempt to explain parthenogenesis and fertilization on the same basis. According to this theory he held that the essential feature of both processes was a cytolysis of the superficial layer of the egg, but that this action in itself would result in the death of the egg unless brought to a halt by the life-saving act of a second agent. The first action he conceived to be brought about by a hypothetical substance borne by the sperm, whereas the second was another hypothetical substance set free in the egg itself.

Much evidence has been brought forward to prove that in parthenogenesis the corrective factor alone will suffice, and that the conception of superficial cytolysis could not be sustained. To overcome these difficulties Lillie suggested what is known as the fertilizin theory. It postulates that a substance borne by the cortex of the egg (fertilizin) exerts two kinds of action: first, an agglutinating action on the spermatozoon; and second, an activating effect on the egg. The spermatozoon is conceived, by means of a substance which it bears and which enters into union with the fertilizin of the egg, to release the activating effect of the fertilizin within the egg. This theory has the advantage that it adequately accounts for the facts of fertilization as well as for those of artificial parthenogenesis.

The extraordinary advance of our knowledge relating to the germ cells that took place during the last quarter of a century prepared the way for a cytological inter-

pretation of Mendel's principles of heredity which are now known as the chromosome theory of heredity. A continually growing body of data demonstrates irresistibly that the phenomena of Mendelian heredity are the result of combinations, segregations, and recombinations of the chromosomes in successive generations. This theory is now indispensable as a practical means for the analysis of genetic phenomena. Opposition to it has been shown to arise through a failure to grasp the mechanism of development as conceived by students of cytology, embryology, and genetics. No one familiar with the subject claims that the chromosomes are exclusive agents of heredity. They are looked upon as modifiers in a reaction system, the results of which activity are determined not alone by the chromosomes, but by the whole system of which they are a part. They are differential factors of heredity rather than the central governing elements.

The behavior of the chromosomes in the maturation of egg and spermatozoon not only furnishes an exact parallel to the genetic behavior of the postulated Mendelian factors, but crucial situations have also been met with that have furnished very strong confirmation of the chromosome theory. Other genetic phenomena such as linkage and crossing-over, that were unknown to Mendel, have also been brought into close relationship with chromosome behavior. From a consideration of linkage and crossing-over, still further possibilities have presented themselves that promise to throw light on the configuration of the hereditary elements borne by the chromosomes. The analysis of crossing-over in relation to the chromosomes, carries us into a region far beyond the visible limits of even the most powerful magnifications that are possible today. In this respect genetics has proved a more refined instrument in analyzing the constitution of the germinal material than the direct observation of the germ cells themselves.

(To be continued in June.)

MATHEMATICS A USEFUL BUT SLIPPERY TOOL.

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That mathematics is the most useful tool of the scientist cannot be denied; there would be little or no science without it. But that it is the only rigidly exact science and is always absolutely reliable, needs to be qualified. There is no denying that it is exact and reliable when properly and intelligently applied, and that it is a necessary part of the education of the enlightened, but the very fact that it is an exact science has developed a confidence in it which has led many into pitfalls, because they did not apply it intelligently and understandingly.

This has led some even well educated men to make and even publish absurdities, which reflect seriously on their intelligence and on the reputation of the schools and colleges where these absurdities are taught by them to their students. Merely teaching the orthodox mathematical processes is not sufficient, the students should also be taught how to use them intelligently, and how to avoid the pitfalls which an unintelligent use leads to. A workman may have been given the very best of tools, yet if he does not also learn how to use and handle them properly they may be not only of no use to him but may even injure him and his reputation.

The purpose of this article is to call attention to some of the pitfalls that an unintelligent or careless application of mathematics may lead to, and to show how some of them may be avoided. This refers only to applied mathematics in which the results have a real or useful meaning, and not so much to mere mathematical exercises for drilling one in the processes, nor to mathematical jugglery or mere intellectual entertainment.

One of the first things is the necessity of realizing and understanding what a mathematical operation and its result really mean. Thus we may multiply three oranges by four apples and get 12. The mathematical part is unquestionably quite correct, but neither it nor the result mean anything at all. While this is very evident in this homely illustration, it is often by no means so evident in many more complicated mathematical operations, as in algebraic, and more particularly in calculus calculations in which the process sometimes obscures the meaning of the result; or the physical meaning is not properly followed or understood, although quite as important as the mathematical part.

Thus in a certain quite important case in which the results had been accepted for many years, it was recently found that the summing up process of integration had been applied to a series of results which had already been added together. For instance, if there is a running unpaid account of items for a year, in which the statements at the end of each month are already the sums from that date back to the beginning of the year, one must not add these together for the total, as they are already totals to date. This simple case is very evident to the one who pays the bill, but there are other similar though more involved cases in which it is not so evident, but requires some thought and careful investigation.

The difference between pure and applied mathematics is well shown in the following illustration which, though homely, is representative of many less evident cases. A snail at the bottom of a hole 100 ft. deep crawls up 30 ft. per day, but slips down 20 ft. at night, how long will it take to get out. According to pure mathematics, used without thought, it would take 10 days, but a little thought shows that this would mean that on the 9th day it had crawled up 20 ft. in the air above the hole, which is absurd. According to applied mathematics, used with some thought, the snail gets out on the evening of the 8th day, and being out of the hole it of course does not slip back again. In applied mathematics one should always realize what the mathematical processes really mean and involved. Even the expression $\sqrt{-1}$ has some meaning in practice.

If the regular way of solving a mathematical problem is difficult because it is puzzling or confusing, it is a good rule to try to solve it in an entirely new and different way, perhaps backward. There are for instance a number of very good problems to figure out a loss, stated purposely in a puzzling way, to which very few people will at first give the correct answer; in one case as many as a dozen wrong answers were often given. The simple fact that the loss by one party must necessarily be equal to the gain of the other, solves the problem easily, as the gain was easily computed. More serious confusing problems may often be readily solved similarly by attacking them in an unorthodox way.

In some cases in practice a factor, quantity, or relation, necessary for the solution, is not given in the conditions of a problem, but resides in the nature of the problem and must therefore be supplied by the solver of the problem, or at least

be temporarily represented by a letter in algebra which may perhaps cancel out, hence need not be known numerically. The writer recently had an important case in mathematical physics which involved the relations of several unknowns, but there was one equation or relation less than was necessary, thus making it unsolvable. It was impossible to deduce another relation from the theories involved, although it was known what this relation ought to be. Finally it was found that this missing relation was not inherent in the problem itself, but was of the nature of a voluntary condition which could be imposed by the conditions under which a physical test was to be carried out, such as the law of variation of a certain opposing force, which could be made anything desired by the experimenter without affecting the laws of the problem itself. By adding this relation to the problem its solution became very simple. This shows how an apparently impossible mathematical problem may sometimes be solved by a more intimate knowledge of the true meaning of the mathematical processes and relations involved.

Text books on mathematics may describe all the regular, every day, orthodox, mathematical processes, but they often fail to say anything about the odd and unusual things which sometimes arise in the practical applications of mathematics. For instance, in simplifying and reducing a complicated algebraic equation we are taught that if the same factor occurs on both sides of an equation it may be canceled out, no matter how complicated this factor may be, or what known or unknown quantities it may contain. But this may at times be very dangerous, for if this factor happens to be equal to zero, which it may be impossible to determine at that time, the rest of the calculation may be absurdly wrong. In a well known case of this kind it is possible to "prove" the absurdity that $1=2$, from which further absurdities can be deduced. If the canceled factor is a complicated one involving the unknown quantities, it may be impossible to find out whether it is zero until the problem has been solved, and if solved after cancellation the solution may be an absurdity.

On the other hand, sometimes such canceled factors may be made equal to zero and solved as a separate equation, giving one of the roots of the original equation. In this case we know the factor to be zero because we made it so, and yet the remainder of the original can still be relied upon. Do the teachers and

books always make it clear in which cases it leads to absurdities and in which it does not?

In a certain case, in which all the steps were perfectly correct, the final answer was $2x=2x+30$ which leads to the absurdity that $30=0$, and gives no value for the x . Probably few books if any, tell us that in such a case the only correct value of x is infinity. The values of x in the equation $x+2\sqrt{x}=3$, by the regular method, are 1 and 9, yet the latter does not satisfy the equation. Solving the equation $x-a=\sqrt{x^2+a^2}$ in the usual way by squaring and reducing, gives $x=0$, which however does not satisfy the equation and is therefore wrong. If the equation $x^2-1=0$ is divided first by $x+1$ and then by $x-1$, a student might conclude that $+1=-1$. Many other illustrations could be given of cases in which the orthodox teaching of mathematics does not suffice to meet cases occurring in practice; worse than that, we may rely on the answer when in fact it is wrong.

In some cases the physical laws as stated in books for many years, have been found to be incompletely stated and sometimes actually wrong. While this was sometimes caused by an incomplete knowledge of the physical part, yet the error will then appear in the mathematics of such cases and in those deduced from them. For instance, Maxwell, whose mathematical system of treatment of electrical problems is universally taught, did not recognize the existence of an internal tensional force in every conductor carrying a current. Hence this force, being absent in his fundamental mathematical expressions, cannot, of course, ever appear in any mathematical deductions from these fundamentals. This has for years led many to believe that such a force cannot exist, when it is easily proved experimentally that it does exist. A loop of flexible wire, for instance, laid on a table in irregular form, will expand into a circle when a sufficiently large current is passed through it. The greater radial pressure of the flux inside the loop causes it to expand into a circle and this radial force is necessarily associated with a longitudinal force in the wire, quite analogously to the tension in a soap bubble film or in a toy balloon. The moral of this is that a factor once dropped in the original fundamentals in a mathematical system, is lost and will never reappear afterwards in any subsequent mathematical deductions from these originals.

The following is an interesting case in which higher mathematics actually gives an erroneous result and therefore is a

warning. In the case of a circular tensional force, like that in a stretched rubber band, stretched into a circle, the calculus says that in each differentially small element of it, the two forces are equal and directly opposite, hence can produce no radial force perpendicular to them, which is according to rules as taught. Yet it is perfectly well known that such a stretched rubber band *does* produce very decided radial forces, notwithstanding the mathematical result. This shows that serious errors can arise from even correct mathematics, correct merely in following rules, especially in the calculus which is now being used quite freely and glibly though sometimes thoughtlessly and even senselessly by the many who merely follow a rule of thumb and do not realize the real meanings of the processes and results involved. This is especially true of young men fresh from college.

In many cases results are stated in certain units, when they really refer to some other units, perhaps in part only, thereby causing confusion and even absurdities. Thus forces and pressures (which are forces divided by areas) are often confused with each other; so are power and energy; in electricity volts have sometimes been expressed in terms of ohms, farads in terms of henrys, etc. A length multiplied by a length perpendicular to it, will be an area, but when in the same direction it means nothing. A force multiplied by a distance gives energy when in the same direction, but when perpendicular to each other it means merely a torque, which is not energy at all. Acceleration is used with two different meanings. This leads to vector quantities. In some cases this confusion can be avoided by testing a mathematical formula by its so-called "physical dimensions," which should always be done in any doubtful cases. An angle however unfortunately has no such dimensions.

One of the most dangerous and confusing factors in mathematics is the zero. Some mathematicians even claim that there are several "kinds" of zeros. We are told that it simply means nothing, the absence of everything. But nothing divided by nothing, that is $0/0$, is "anything," large or small, (mathematically called an "indeterminate"), thus making something out of nothing! Mathematically this division means that zero will go into zero *any* number of times and leave no remainder, which is correct; yet 0×0 is 0, even though in mathematics a division ($0/0$) is merely a multiplication by a reciprocal.

The rule that any number raised to the zero power, such as

3^0 , always equals unity, in which case a zero (that is, nothing) reduces 3 to 1, also confuses the student, though it becomes clear when written $x^n/x^n=1=x^0$. But there are exceptions even to this, because 0^0 and ∞^0 are not limited to unity but may be any number. A zero standing alone, seems to be perfectly safe from leading to any pitfalls, but whenever it is combined with anything else one must beware. For instance, $0 \times 2 = 0 \times 3$ is correct, but canceling out the same quantity on both sides, gives $2=3$ which is absurd. But to say that we must never cancel a zero on both sides of an equation, is not correct either, as in some cases it is quite correct and merely eliminates one of the roots of the equation.

When a mathematical deduction leads to an "indeterminate" it merely means that that particular method gives no result at all, and that some entirely different method of solution must be used; the real result may be a very definite, finite, number. Thus if a and b are both made unity in the expression $(a^3-b^3)/(a-b)$ it gives $0/0$ which is indeterminate, that is, no result. But if the indicated division is carried out first before substituting, the answer is 3, which is the correct one.

The grave danger inherent with indeterminates, involving serious pitfalls into which many even able men have fallen, is that sometimes they are not properly recognized, and a result like 0 or ∞ is obtained when a more careful investigation of the mathematical process may show that it is really an indeterminate, and the result may therefore be a definite, finite, number instead of 0 or ∞ . This has led to serious errors, showing some quantities to be infinite when they are really finite and determinable. This may arise for instance by a factor being mathematically absent, say by being made unity, or lost sight of in a ratio, but is still physically present in the result; hence a result carelessly obtained as ∞ may perhaps be ∞/∞ , or $0 \times \infty$, or $\infty - \infty$, or $0/0$, etc. all of which are indeterminates, and may have definite, finite, values.

Great care should therefore be taken in such mathematical deductions in which the result seems to be zero or infinity, that it is not really an indeterminate, and if it is, it merely means that that method of solving the problem must be abandoned as incapable of giving any result, and a new and different kind of a solution must be looked for. All indeterminates seem to involve zeros and infinities. The following seem to include the principle ones, $0/0$ or 0^0 , ∞/∞ or ∞^0 , $0 \times \infty$, $\infty - \infty$, 1^∞ .

There are also distinctly different ranges of magnitude in mathematics which should be carefully kept separated. Thus there are the very useful infinitely small quantities used in the calculus; then there are the finite values used in practice; and finally the very large infinities. Adding a finite quantity to infinity, for instance, does not affect the infinity and may therefore be dropped and should not cause confusion.

But the worst and most dangerous and treacherous of all the pitfalls in mathematics are due to a supposed knowledge about the properties of the quantity called infinity. People who talk glibly about infinities are very apt to fall into such pitfalls, as they are luring, and statements about a knowledge of the properties of infinities appear to display alleged wisdom, and they are somewhat safe in the sense that a proof of denial is often as difficult as to deny the existence of a heaven or future life. There is probably no other element in mathematics which has more often led even able men to making absurd statements, than infinity. Some have even made the inexcusable error of extrapolating an approximate formula to infinity.

In a book by Fleury, a Frenchman, devoted largely to this subject, he says: "Infinity has no other property than that of being impossible. Any calculations based on absolute infinity or upon any function whatsoever of absolute infinity, is itself absurd. * * * Whenever in mathematics we come up against a stumbling block, a scandal, or a paradox, you can ask *where the infinity is*; I mean that the error is the result of attributing some false property to infinity."

The last line of an English college limerick also contains wise advice: "There was a young student of Trinity, who found the square root of infinity, but in writing his digits he soon got the fidgets, dropped science and took up divinity."

The writer's easily remembered advice about infinity in mathematics (as it does crop up occasionally) is: when you reach infinity, stop and go no further.

When a result has been deduced mathematically, involving infinities and zeros, and is then used by itself as a finite expression, it may be even more dangerous, as it is likely to be tainted with some of the absurdities of infinities, and the innocent and unsuspecting victim using it in its finite form may not be aware of its previous history. Only recently such a case appeared in a prominent scientific journal, which has doubtless deceived many. When quantities appear as letters in algebraic expres-

sions, it is not always plainly evident that their values may at times and under certain conditions have been zeros or infinities, and that the deductions should have stopped there and be carried no further. Sometimes this may have been overlooked innocently, by the careless; sometimes it may be used to "prove" a point in an argument, in which case it may become a boomerang.

When the mathematical properties of something pertaining to a straight line are deduced from those of a circle, infinity necessarily creeps in, as a straight line may mathematically be considered as a circle with an infinite radius. When once involved in such deductions they are ever afterwards tainted with infinity absurdities. The infinity cannot afterwards be eliminated by division or subtraction of an infinity, as both of those expressions are indeterminates. The physical properties of anything based on a straight line had therefore better be deduced independently and not from those of a circle.

In some cases expert mathematicians may perhaps be able to make some rational deductions from expressions containing infinities, but this should be left to the real experts and should be earmarked, and even then such results should be "handled with care," as they may be tainted.

There are two ways, and perhaps only two, in which infinities may sometimes be dealt with rationally in applied mathematics in practice. One of these applies when it is possible to assume that the quantity is simply so large (though finite) that others which depend on it may safely be taken as the same as they would be if it were infinitely large; this is very often the case. For instance when a man is talking in New York it can be safely assumed that he is not being heard in London or even in the next block, those distances being practically infinite as far as the sound waves are concerned, although theoretically some of the sound waves must reach those places. Simultaneous electrical tests may be made even with great accuracy in buildings near each other, though some of the magnetic flux theoretically must reach from one to the other. Such finite "infinities" might be called practical infinities. When thus made finite, the indeterminates which involve infinities, are avoided.

The second applies when some *property* of an infinite quantity can be found which is really finite, and therefore can be practically applied. Thus with some curves that extend to infinity, the area between them and their ordinates, is finite. The pres-

sure of our atmosphere is finite, although theoretically the atmosphere must extend to infinity according to the laws of gases. The magnetic flux around a single straight electrical conductor extends to infinity but its magnetic pressure on the wire is finite, and it has recently been shown by calculations which are free from infinities, that the energy stored in this infinite flux, is finite, per unit of length of conductor, although the older formulas which were tainted with infinities show this energy to be infinite.

The trust we can place in the reliability and accuracy of that most useful of all tools, mathematics, has sometimes obscured the fact that there are also many pitfalls for the one who uses it. Some fall into these snares innocently owing to ignorance, or sometimes to the faults of their teachers or books; and to some who are willful the old proverb applies that "figgers can't lie but liars can figger."

DEADLY GERMS HARMLESS IF NOT IN RIGHT PLACE.

Germs of diseases that are deadly to an animal or a human being if they find their way into the part of the body they usually afflict, may be entirely harmless if they are planted in another organ or tissue. Doses of anthrax germs a thousand times larger than an ordinary fatal injection have been introduced into the bodies of guinea pigs with no more effect than so much salt water; yet if the slightest trace of the fluid containing them found its way into a scratch on the skin, the animal very quickly died.

These experiments, which promise revolutionary results in the sciences of bacteriology and pathology, are being conducted at the Pasteur Institute in Paris by Dr. A. Besredka, a young Russian scientist, according to Dr. Erwin F. Smith, pathologist of the U. S. Department of Agriculture, who has just returned from a tour of inspection through European laboratories.

Dr. Besredka, he says, has discovered an entirely new principle in bacteriology which has been named "local immunity." According to this principle, disease-causing organisms are frequently quite impotent to do harm away from their usual habitat. Anthrax, for example, is always an affliction of the skin and surface tissues. Dr. Besredka devised means for planting cultures of the germs deep in the muscular tissue, in the lungs and elsewhere in the bodies of guinea pigs. Aside from a little inflammation, probably due to the mechanical irritation of the instruments used, the animals showed no signs of harm from the usually deadly organisms. Less serious skin infections, like those caused by staphylococcus, the germ of boils, were shown to act in the same way.

Dr. Besredka's discoveries have already become of practical importance in medicine. After showing that susceptibility to bacterial infection was local, the Russian scientist also showed that immunity could be conferred more effectively by serums and other preventive means if applied equally directly to the regions usually attacked by the disease. Since typhoid fever is a disease of the digestive tract, Paris physicians are now following Dr. Besredka's principle, and administering anti-typhoid serum through the mouth rather than by means of injection into the arm. Dr. Besredka claims that when administered in the ordinary way the serum gets no chance to act until the blood has carried it from the muscles of the arm into the intestinal tract.—*Science Service.*

ON CERTAIN CRITICISMS MADE BY PROFESSOR
G. A. MILLER.

BY JEKUTHIAL GINSBURG,

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In the first volume of the *Bibliotheca Mathematica* there appeared a series of "Kleine Bemerkungen" by the late Gustaf Eneström and certain other contributors. These notes related to Cantor's *Geschichte der Mathematik*, and every succeeding volume continued the series, each throwing new light upon some special point in the history of mathematics as treated in Cantor's monumental work. The great value of these remarks was immediately recognized by scholars, and this appreciation is further apparent from the references to them in the various histories which have since appeared. One of the catastrophes of the World War was the drying up of so many sources of scholarly production, and as part of this process there was the discontinuance of the *Bibliotheca Mathematica* and the cessation of the constructive and scholarly criticisms of Eneström and his collaborators.

Within the last few years Professor Miller, of the University of Illinois, has published various articles and marginal notes or remarks upon such works as the *Jahrbuch über die Fortschritte der Mathematik*, the *Encyclopaedia Britannica* Webster's New International Dictionary, Murray's large English dictionary, the *International Encyclopedia*, and the histories written by Professors Smith and Cajori, supposedly with a view to performing a service similar to that rendered by Mr. Eneström. As a result there have appeared from his pen several hundred items of criticism,—an ambitious effort for anyone meaning, as it does, an attempt to throw light upon hundreds of "dark corners" in research, and presupposing the qualifications of such scholars as Eneström, Tannery, Curtze, and a large number of others who assisted in preparing the critical notes for the *Bibliotheca Mathematica*,—various questions have naturally arisen as to whether these criticisms are valid, whether they are based upon original source material, whether they are fair in their interpretation of statements, and whether the articles of Professor Miller really contain new information justifying changes in the works criticised.

If the answers to the questions are favorable to Professor

Miller, then an injustice has been committed against him, for all the writers on the history of mathematics have apparently agreed in ignoring the articles entirely. If on the other hand, the answers are not in his favor, then not only has an injustice been done to the works criticised, but a still greater injustice has been done to those readers who have placed reliance upon Professor Miller's strictures. As he has himself stated, "The destruction of undue confidence is an important step in the study of the history of science."

Having been requested by a publisher to consider a certain line of these criticisms, the writer became interested to examine a number, and probably all, of the recent articles of this kind written by Professor Miller, and has extended his investigations by a careful perusal of the latter's own treatise upon mathematical history and bibliography. As a result of his study he is convinced and is prepared to offer evidence to support his belief that, aside from a relatively small number of references to misprints and minor slips of the pen, upwards of eighty per cent of the criticisms of fact have no justification whatever.

These criticisms may be divided into two general groups: (1) those which he seeks to justify through the opinions of other writers, where judgments may differ, and (2) those based upon Professor Miller's own interpretations and opinions. As to any dependence upon source material, his articles seem to show that substantially no such material was consulted and no new light has been thrown upon a single historical question at issue. While a hundred "Bemerkungen" of Eneström meant a hundred new facts discovered,—material of value to every student and historian,—in the case of Professor Miller (who has placed his own contributions in the same class¹) they mean at the most a hundred conclusions, mostly incorrectly drawn from a few (and a pitifully few) secondary sources, statements which may be true or may be false, and statements which are of convincing value only when checked from the original documents or made reasonably probable by the general consensus of opinion of critical scholars.²

To justify the statement above made as to reliability, a few illustrations of Professor Miller's methods will be offered. Let

¹SCHOOL SCIENCE AND MATHEMATICS, XX, 300.

²It is interesting to observe that no recent writers on the history of mathematics seem to have found anything of value in any of these criticisms. Tropicke, for example, whose list of references to Eneström exceeds one hundred, and who freely draws from books and articles by such writers as Smith, Cajori, Archibald, and Karpinski seems to have ignored Miller entirely.

it not be assumed, however, that these are exceptional; if the space were available, the writer would be glad to furnish a complete list of the criticisms, with a statement showing their general unreliability. The first two here adduced, relating to statements in Professor Smith's *History*, are merely typical.

1. Professor Miller asserts: "It is not now generally believed that the results of Eratosthenes were as nearly accurate as is here stated," with reference to a secondary source, the French edition of *Encyclopédie*³, "tome 6, volume 1, page 6." (See SCHOOL SCIENCE AND MATHEMATICS, XXIV, 942.)

It is interesting, however, to see that this work gives identically the same result as is found in Smith, except that it states it in kilometers instead of stadia.

2. "It is here stated that the Hindus developed a numeral system which is 'the most extensive to be found among any ancient people.' On page 5 of volume 1 (1921) of Tropicke's *Geschichte* . . . it is noted that also in China 10^{53} was used as a kind of base of a number system dealing with very large numbers." (See *ibid.*, XXIV, 940.)

But what Tropicke says is something quite different, viz., that the Hindu and Chinese Buddhists simply tried to picture the inconceivable by means of very large numbers such as 10^{53} , and in any case the Buddhistic religion was developed in India and hence the statement of Tropicke (assuming that his work should be treated as source material) merely confirms, instead of contradicting, Professor Smith's statement. Since Tropicke simply quotes from Woepeke, who was also Cantor's (*Geschichte*, I (3), 669) source, it is interesting to observe that an examination of Woepeke's article (*Journal Asiatique*, I (6), 257) shows that we have to do with a Hindu idea adopted later by Chinese Buddhists.

The next three criticisms relate to Professor Cajori's latest revision,

3. "The statement that Apollonius did not discover the focus of a parabola should be compared with the following: 'It is certain that Apollonius was aware that an ellipse has the property of reflecting all rays through one focus to the other focus. Nor is it likely that the corresponding property of a parabola with reference to the axis was unknown to Apollonius.' (Heath, *Greek Mathematics*, II, 200.)⁴

³*Encyclopédie der mathematischen Wissenschaften.*

⁴SCHOOL SCIENCE AND MATHEMATICS, XXIII, 140.

But what has this to do with "the focus of a parabola?" Heath himself states (Apollonius, p. 112): "The focus of a parabola is not used or mentioned by Apollonius." Professor Miller has simply made one of his unverified guesses without going to the source.

4. "We also do not know that the Eudemean Summary is an abstract from the works of Eudemus as stated near the bottom of page 15. Cf. Heath, *l. c.* [*Greek Mathematics*, vol. 1], p. 118.⁵

Now what Professor Cajori really says is this:

"A full history of Greek geometry . . . written by Eudemus . . . has been lost. It was known to Proclus who, in his commentaries on Euclid, gives a brief account of it. This abstract constitutes our most reliable information. We shall quote it frequently under the name of Eudemean Summary." (Cajori, *History*, 1919 ed., p. 10).

What Heath says (*Greek Mathematics*, I, 118), is this:

"Down to a certain sentence it [the Summary in Proclus] was probably based, more or less directly, upon data appearing in Eudemus' *History*."

In other words, Professor Cajori is criticised for a thing that he never said.

5. "The statement, 'It is worth noticing that it was Pappus who first found the focus of a parabola, should be compared with our note on p. 41 as well as with note 115 in the *Encyclopédie des sciences mathématiques*⁶; tome 3, volume 3, p. 2." (*School Sci. and Math.*, XXIII, 140.)

Here again an attempt is made to give the impression that the author is at fault, whereas, as already shown (No. 4), Professor Miller has himself erred.

It may be felt that Professor Miller, even though unreliable in cases demanding scholarship on the part of a critic, has assisted readers by calling attention to misprints or slips of the pen. No one would deny the value of such corrections in a text; any good high-school pupil could make them, and that a professor in a great university should give his time to perform the task shows a spirit of sacrifice that commands attention. As compared with constructive criticism based upon a study

⁵SCHOOL SCIENCE AND MATHEMATICS, XXIII, 139.

⁶The French translation of the German *Encyclopädie* already mentioned. The account does not differ from that given by Professor Cajori but it mentions a conjecture by Zeuthen.

of original sources, such as characterized the work of Eneström, this does not seem to place any intellectual burden upon the critic, but it is a worthy pastime and is helpful to the world. Moreover, Professor Miller is certainly not an authority even in these matters. A glance at his own book upon the history of mathematical literature would remove that impression. When, for example, he criticises an author for using capitals in the expression "Spirit of the Times" (*School Science and Mathematics*, XXIV, 944), and seeks to give the impression that he has discovered an error, he really gives an impression which is not at all to his credit. Likewise, when an author refers to Hankel's *Entwicklung*, giving the date 1884, which is the latest and presumably authoritative edition, he is criticised for so doing. If it were a medieval manuscript, where the date of the first appearance is of major interest, the earliest date should, of course be given, although in his *Introduction* Miller himself violates this very rule in the date which he assigns (p. 132) to the *Liber Abaci* of Fibonacci. He also holds up⁷ as an error a statement about the 73d term in a certain series, saying that it should be the 72d, when in fact the 73d term in the series $6, 6\frac{1}{4}, 6\frac{1}{2}, \dots$ is precisely 24 as stated, unless we assume that 24 hours is not a day period. In criticising Professor Cajori he makes a great point⁸ of the fact that the expression "Vieta and Descartes" should read "Vieta to Descartes," whereas this is precisely what is done in the running heads of the *History* (pp. 145-172), the form "to" being a single misprint in the Contents. If he were looking for misprints, he would find a very fertile field in his own *Introduction*. Similarly, he attempts⁹ to make a great point of the fact that the index to volume I of Professor Smith's *History* (a survey of elementary mathematics) does not include the names of Enriques, Hadamard, Hilbert, Hobson, Klein, Moore, Peano, and Russell. Four of these appear, however, in the index to Vol. II, a fact which shows the unfairness in not holding such a criticism until the second volume is out; and as to the rest, not one appears in Tropfke's *Geschichte*, the only general history of mathematics which he makes a point of holding up as his standard authority.

Perhaps the most amusing of his canons of criticism is the one which allows him to condemn a volume on the history of

⁷SCHOOL SCIENCE AND MATHEMATICS, XXIV, 945.

⁸SCHOOL SCIENCE AND MATHEMATICS, XXIII, 138.

⁹SCHOOL SCIENCE AND MATHEMATICS, XXIV, 947.

elementary mathematics because there are more index references to such writers as Karpinski, Cajori, and Steinschneider, than to Descartes.¹⁰ Since these writers published many memoirs on the history of the subject and Descartes published none, it would be interesting to know the basis of the canon. The amount of space devoted to Descartes under the single reference is, of course, far more than that devoted to any one of these other men, a fact which the critic is careful to conceal.

Professor Cajori (*History*, 1919 ed., p. 23) speaks of Antiphon's idea that an inscribed regular polygon would, by increasing the number of sides indefinitely, become the circle. For this the historian is criticised (*SCHOOL SCIENCE AND MATHEMATICS*, XXIII, 140) by saying "there is no such last polygon,"—as if the error were Cajori's instead of Antiphon's. He might equally well have criticised Heath (*Greek Mathematics*, I, p. 222) or various other recognized historians for similarly stating Antiphon's theory.

Another single illustration of his method of criticism is seen in his objection to Professor Smith's statement that the Greeks had fully mastered the general quadratic equation, his ground being that they "could not solve such equations when the roots are either negative or imaginary."¹¹ Of course they did not,—nor the number of roots, nor the symmetric functions of roots. The statement manifestly means, as the context shows, that they could give a geometric solution of a quadratic of the general type. Would Professor Miller criticise his own statement, made in the *Popular Science Monthly* in 1910, p. 461, that the idea of permutation groups was "clearly developed" by Ruffini, although, he could not have known the later results obtained by Cauchy, Sylow, and others?

Having, as above stated, examined with care most if not all of Professor Miller's criticisms of the books mentioned, the writer feels it his duty to assert that such criticisms from this source show a want of scholarship and of exactness that is lamentable, and that they should be accepted only after the most careful scrutiny. If *SCHOOL SCIENCE AND MATHEMATICS* will allow the space, and if the editors feel that readers will be further assisted thereby, I shall be glad to publish in condensed form all the criticisms referred to, with a statement as to the validity or lack of validity of each.

¹⁰*Ibid.*, p. 947.

¹¹*SCHOOL SCIENCE AND MATHEMATICS*, XXIV, 942.

**A TENTATIVE CURRICULUM FOR A TEACHER-TRAINING
COURSE IN HIGH SCHOOL BIOLOGY.**BY **FREDERICK H. BLODGETT,***New York University, Washington Square Branch.***INTRODUCTION.**

It has been customary, and still is so in average localities, to appoint as teachers in high schools, persons who have had college training in their special field, but the factor of skill in teaching is rarely considered. The idea as seen in practise is that a knowledge of the subject will carry ability to teach the subject to others. This is too great a contrast to the rule in elementary work, in which specific training in the art of education is required of practically all candidates before appointment.

Several statistical studies of high school subjects indicate that the choice of the electives is chiefly in reference to college entrance requirements; interest in the subject itself being of less importance than its promotion value. This applies to science subjects as well as others, with the possible exception of physics, which now is of popular interest because of radio amateurs. With daily press notices of scientific achievement in one or another field, in locations scattered over the whole globe, the query arises as to the reason for the general indifference shown by the average high school pupil toward the field of science; the answer presents itself with an atmosphere of at least partial explanation—"poor salesmanship on the part of the teachers."

The successful salesman in modern competition needs to know his goods, as a matter of course, but even more important for his commercial success is a knowledge of his purchasing public and a selling skill for his particular line of offerings. High school teachers have as a rule had little if any training along the lines of applied psychology as the elementary teachers have had, and they are to that degree handicapped in the presentation of their subject (if the training itself is of actual value in teaching).

The "Tentative Curriculum" here outlined is based upon the average requirements in child psychology, and technique of teaching by normal schools, with a progressive program of topics in the field of knowledge—science—which the prospective teacher is assumed to have selected for special attention. Within the special field training in the art of teaching is developed by due attention to observation and practise of procedure in class rooms and increasing responsibility for instruction in the science groups of topics, as is usual in other fields of instruction.

¹Dr. Blodgett died in New York City, March 4th.

DISCUSSION.

(The following discussion is based upon the work done in connection with the course in Professional Education, s227M, of Teachers College, summer session of 1925.)

The increasing attendance at normal schools generally indicates the expectation by the public that those placed in charge of the education of children shall receive definite training for that activity. In the catalogs it is common to find the studies required of the prospective teachers grouped under three heads; cultural, professional, and special. While the titles of courses are often confusingly different in separate catalogs, the general education which is expected of any one, the particular training of a teacher, and the knowledge of the chosen field of future activity are the evident considerations in the make up of the courses offered. These three divisions of training are recognized in the following outline, but the regular topics of cultural and of basic professional nature will not be taken up in detail, as they are sufficiently standardized to offer no controversy or misunderstanding as to scope or purpose.

The first appearance of special topics in the course suggested, is the substitution in the work upon composition and literature of the writings of men eminent in the several fields of science, in place of the ordinary "English Literature" exercises. By co-operation between the science department and the English teacher a suitable selection could be arranged for the required training in this topic. Huxley and Agassiz, Darwin and Pupin, Ceik'e and Russell, have written of incidents observed by them in language as suitable to follow as examples as Stevenson or Thackeray, while Thoreau, Burroughs, and Muir tell of changing seasons and nature's moods as acceptably as Dickens or Holmes express their characters. Of the total allowance for history, about one half is here allotted to the study of the development of the field of science as a definite part of history; in fact many details of political history will be more clearly understood when the relations of exploration, discovery, and achievement are developed in connection with the times and peoples most concerned.

In connection with sociology and political economy, or their equivalents in the program, little change need be considered; but the world relations to food crops, and the relations of labor to employment in connection with the development of industry through the application of scientific achievement to past condi-

tions would properly be emphasized somewhat more than in a course for teachers of literature. It is to be remembered that these courses are being offered (in this discussion) to graduates of high schools, who are taking the college type of studies in a teacher training school with a four year program, and the presentation of subject matter will therefore be on the college level of instruction, so that a broad understanding may be gained beyond that actually required for transfer to the pupils anticipated to be present later on. This would permit an elasticity in the presentation of the field in actual teaching not possible if training were confined to the limits of prospective use alone. But in the observation and practise teaching details, the training should be largely in that group of class rooms which will form the field of activity for the student upon graduation and assignment to independent work.

BRIEF SUMMARY OF BIOLOGY, TO SHOW CONTACT VALUES AS A
TEACHING SUBJECT.

I. The field of biology deals with living organisms of the earth, and the first step would be to get in touch with the characteristics of *life* in contrast to matter or motion.

II. All life depends upon the utilization by organisms of different details of the earth's crustal region; some in water, others in soil, others in air, as chief medium.

III. Life manifests its presence by activities of the individual, made possible by structures characteristic of the various forms known, for maintenance, growth, reproduction.

IV. With elaboration of structures in size, need of control and of nutrition of the remote parts is apparent in development of special tissues, in both plants and animals.

V. Plant life furnishes the required nourishment for animal forms, which feed upon vegetation; but movements of feeding animals often of benefit to plant life (dispersal).

VI. Interrelation of plant and animal life, and the principles of development form the basis of all stock and crop raising, as well as of wild life of field or forest.

VII. Applications of recent discoveries in activities of living things, has made possible the great industries of Armour, United Fruit, U. S. Rubber, and Minneapolis flour.

VIII. Discoveries of desired qualities in distant forms has resulted in importations of better crops and animals, but frequently accompanied by harmful associates. (Pests).

IX. The relation of human health to activities of insects and their parasites, was a discovery which expanded the span of life to duplicate the benefits of germ discovery.

X. Continued study shows mankind to respond to essential principles of animal activity, but under such slight or great modification as stage of civilization may determine.

XI. The development of voluntary association in numbers within a common area, lies at the bottom of national development in history; local conditions influencing "culture."

XII. Discovery of means of control of forces of nature by man has made possible the age of machinery; but the life of the population rests as always upon the life of plant and animal forms suited to use by mankind as foods in great quantities and reliable supplies.

The points just listed do not fully cover the field of contact, or show the scope of the subject matter discussed in one manner or another under the title biology. But they will serve as a blackboard sketch of the idea in mind as to the characteristics of this field of instruction in contrast to others of common acquaintance, and the possible contacts between them. It may be well to state briefly the pedagogical relations of a training course in biology to the teacher entering such training and to the pupils in whose education such a teacher may be expected to have a share. The following short statements aim to show this relation.

PROFESSIONAL TRAINING FOR HIGH SCHOOL TEACHERS OF BIOLOGY.

I. Function of a professional course in biological science. To contribute to the training of individuals for becoming successful teachers of biology in high schools, by a knowledge of the subject, appreciation of its social significance, and familiarity with methods of teaching biology in high schools.

II. Objectives of the training course in biology for high school teachers:

1. To give a knowledge of field or subject matter to be taught in high school.
2. To give teacher acquaintance with nature of pupil-groups to be instructed.
3. To give familiarity with materials suited for use in instruction of pupils.
4. To give training in methods to be employed in utilization of materials.
5. To develop technical skill in instruction of high school classes in 1 to 4 supra.

III. Outcomes which may be expected from the training of prospective teacher:

1. Ability to plan lessons for high school work suited to pupils affected.
2. Judgment as to content of such lessons, adjusting teaching to environment.
3. Technique in the use of materials or sources of information, laboratory, library.
4. Contacts with related fields of work, gaining greater range for illustration.
5. Ability to help pupils in various ways, such as—
 - a. Acquiring of broad concepts concerning living things; growth, maintenance, etc.
 - b. Acquiring a sense of the essential unity of nature among living forms.
 - c. Acquiring some understanding of developmental history of representative forms.
 - d. Learning of the contrasts between plants and animals under average conditions.
 - e. Recognizing the influence of living forms upon mankind and his activities.
 - f. Appreciation of modifications in plant and animal developed by man's intelligence.
 - g. Understanding something of flexibility of nature; adaptation of form to place.
 - h. Recognition of personal possibilities for growth toward selected goal in life.
 - i. Appreciation of responsibility of each in association with others of common group.¹

IV. Content of a training course for biological teachers, high school service.

The biological content of the course is listed in the Special Subject group of topics in the curriculum following. Reference is made by number to courses in Teachers College to indicate the nature of the work suggested, rather than writing a description of such courses. Local conditions may of course call for modification from these selections, but they can be regarded as standards for comparison or discussion, if necessary.

THE CURRICULUM.

<i>General Training.</i>		<i>Special Training.</i>	
	Hrs. Hrs.		Hrs. Hrs.
Introduction to Teaching		General Science.....	rec. 3 lab. 2.
(T. C. s228E).....	3	Physical Geography.....	3 2
English Composition I.....	3		
Modern European History.....	3		
School, and Personal Hy-			
giene.....	2		
Physical Education.....	0 2		
Principles of Education			
(T. C. Ed. B 1, 2).....	3		
	14 2		6 4

¹This may be considered as a climax detail, and affords the biological basis for a study of human relations such as we commonly classify under the terms Family, Society, Government, Nation, and Race. The recent experiences of mankind in the World War shows the close relation that remains between even the most elaborate phases of civilized community life and the simple demands of food and clothing, and the absolute necessity of continued supplies of these necessities for civilian as well as for military activities.

SECOND TERM.

Principles of Education (Ed. B1, 2).....	3		General Science, Cont.....	3	4
English Composition II.....	3		Physical Geography.....	3	2
Sociology.....	3				
Modern European History, continued.....	3				
Physical Education.....	0	2			
	12	2		6	6

SECOND YEAR.

FIRST TERM.

Psychology of Adolescent Child.....	3		General Biology.....	3	4
Oral English, for speech training.....	3		Essentials of Agriculture.....	2	2
Economic History, U. S.....	3		Commercial Geography.....	2	2
Physical Education.....	0	2			
	9	2		7	8

SECOND TERM.

Psychology, Advanced Ed- ucational (208D).....	3		Botany in projects, etc.....	3	4
Science Essays, English se- lections.....	3		Bacteriology.....	2	4
Economic History, cont.....	3		Fungus diseases, crops.....	2	4
Physical Education.....	0	2			
	9	2		7	12

THIRD YEAR.

FIRST TERM.

Teaching of science in sec- ondary sch.....	3		Zoology, in projects, etc.....	3	4
Polit. Econ. or Civil Govt. (choice).....	3		Bacteriology, continued.....	2	4
Industrial History, U. S.....	3		Health Laws and Regula- tions.....	2	
Science Essays, American selections.....	2		Field Trips.....		2
Observation of teaching methods (gen.).....	0	2			
	11	2		7	10

THIRD YEAR.

SECOND TERM.

Teaching of Science, High Schools.....	3		General Physiology.....	3	4
Educational History, U. S.....	2		General Chemistry.....	3	4
Science Biographies, Pas- teur, Reed, etc.....	3		Special Econ. Biology.....	2	2
Observation of Teaching, sciences.....	0	2	(Pest quarantine; health inspection etc.)		
	8	2		8	10

Since the teacher is to be engaged in the field of science and especially that science upon which, in its applications and derivations, much of the importance of the United States depends, attention to this side of history, and later on to the industrial side in which utilization of the economic resources of forest and field is considered, is of more importance than the political side of history as part of the professional training of these individuals. The relation of political history to educational development will come up for consideration later on under History of Education.

FOURTH YEAR.					
FIRST TERM.					
Teaching of Biology theory			Advanced Physiology.....	3	3
prinsep.....	5		Organic Chemistry.....	3	6
Practice Teaching, science			Ecology, plant, animal.....	2	2
rooms.....	0	4			
Conferences on teaching					
work.....	0	2			
	5	6		8	11
SECOND TERM.					
Practice Teaching science			Projects and Problems.....	2	4
rooms.....	0	10	Organic Chemistry, cont.....	3	4
Special Problems in Bio-					
logical teaching.....	5 ^a				
History of Biology, facts,					
theories.....	2				
	7	10		5	8

In the above tabulation the separate topics are shown in their relation in time allowance and in sequence during the four year course, but the titles are distributed over three pages. These are condensed in the following resume, for convenient reference.

SUBJECTS AND TIME ALLOTMENTS.

<i>General.</i>		<i>Biological.</i>	
Introduction to Teaching.....	3	General Science.....	3 4
Principles of Education.....	3	Physical Geography.....	3 2
Psychology of Adolescence.....	3	General Biology.....	3 4
Advanced Educat. Psychol.....	3	General Physiology.....	3 4
English Composition.....	3	Essentials of Agricul.....	2 2
Oral English.....	3	Bacteriology.....	2 4
English Science Essays.....	3	Plant Diseases(crops).....	2 4
American Science Essays.....	3	Botany in Projects.....	3 4
Science Biographies.....	3	Zoology in Projects.....	3 4
History, Modern European.....	3	Chemistry, General.....	3 4
History, Economic, U. S.....	3	Chemistry, Organic.....	3 4
History, Industrial.....	3	Ecology, plant and animal.....	2 2
Commercial Geography.....	2 2	Public Health, laws, etc.....	2
Educational History, U. S.....	2	History of Biological Sc.....	2
Sociology.....	3	Special Economic Biology.....	2
Science meth. sec. school.....	3	Practice Teaching, Science.....	2
Science meth. High School.....	3	Practice Teaching, Biology.....	10
Observ. and Conferences.....	4	Special Problems.....	5

DISCUSSION OF TOPICS IN THE SCIENCE GROUP OF THE CURRICULUM.

The purpose of the curriculum suggested is the training of students to become teachers of biology, and the topics listed are intended to lead from a consideration of the general subject of science to the restricted fields of definite biology by a narrowing perspective and increasing attention toward the chosen goal. In general science a foundation may be secured by acquaintance

^aThis is intended to be something of a Seminar period, in which difficulties or achievements may be discussed as of current interest, in place of the formal consideration of "Methods" now provided for in many catalogues. The actual incidents of the training classes or other sources of experience would be the subject-matter of the hour; or in the absence of difficulties, the planning of lessons on suggested topics might be developed.

with the more important facts and principles underlying the several sciences without separation into distinct branches. Physics and chemistry, astronomy and geology, biology and agriculture each have a share in "General Science" of the first year's work. Physical geography is a useful blending of several of these in a definite relation, of special value to later study in biology, as the changes of the earth's surface considered in physical geography is an important factor in understanding the distribution of forms in studying general biology.

In essentials of agriculture, the student will come in contact with the control by man of the activities of nature, especially as to living forms, and also his dependence upon natural laws and phenomena for his achievements. Agriculture is sometimes called "Biology Under Control," and the next step is to consider the two great groups of biological forms which are concerned in this profession. Botany is taken up in the spring semester and zoology in the following fall, so that the activities of buds and seeds may be utilized in the one case, and the migration and hibernation of animals considered in the other. But the basis of study is thought of as quite different from that formerly listed under the title "Structural and Systematic Botany," although many of the facts then considered will of course be examined. The problem and project ideas will be utilized to bring variety and active interest into the work, and a greater range of details than by the older plans. (There are a number of text or guide books for this type of work now available, but these will not be considered just now, as it is the principle involved upon which attention is being directed, rather than the detailed appliances for class room activities.)

The introduction of bacteriology and plant diseases into a course of study such as this, may be defended on the ground of general importance of information along a few lines of bacteriology, the great economic importance of bacterial infections of both man, beast, and plant, and the ease with which germs may be cultivated for study. Nonpathogenic forms would of course be selected in practice for class work. Plant diseases may be due to bacteria, and those which are due to fungus growths may be studied by the same methods as are bacteria, in most cases. This permits two great groups of harmful organisms to be conveniently studied in connection with each other, both as to time and requirements in the laboratory, and as to injurious effects under natural conditions.

The importance of having exact proportions of the food components in culture media forms a convenient contact with chemistry from bacteriology, and the changes produced by the bacterial and fungus activities in animal or plant attacked have interested students of the highest quality in the field of organic chemistry. Hygiene of course connects directly upon bacteriology, and with economics through the public regulations for the maintenance of health in the crowded conditions of cities, or the contributory relations between country and city, through water supply, milk, poultry, fruit, and produce.

The topic of special economic biology in the third year, is intended to take up the economic problems of farmer and lumberman, florist and fruitier, in connection with such injurious insects as Gypsy moth, cotton boll worm and weevil, San Jose scale, etc; agricultural quarantine for these pests, and with closer enforcement the related regulations affecting stock infected with black-leg, hog cholera, Texas fever, tuberculosis, foot-and-mouth disease, and others which appear from time to time. These several forms of "pest" cause very great financial loss every year, and it is an important bit of education in biology to be able to understand why quarantine is established, and to assist in enforcing its rules rather than opposing its provisions.

These considerations lead directly to ecology of plant and animal, since neither the native forms nor the imported pests can thrive except under conditions which afford the necessary water supply, warmth, seasonal duration, and soil conditions to which the particular forms have become adapted. Organic chemistry at this time gives the student a chance to understand the complex nature of the activities of living organisms, though the time allowed will not permit more than an introductory step into the great field of activities among plants and animals producing their characteristic substances.

As the final step in training for teaching biology, fixed studies give place to an opportunity for application of training received, by increased contact with class room activities. Suggestions are encouraged as to topics to be considered from either plant or animal forms of available types, and the study of these as "Problems" or "Projects" gives a direct approach to class room experience in many high schools, for this method is now common in other branches of science, and may well be adapted to biology—though with less facility at present because of fewer guide books available.

It is to be kept in mind that the student is preparing to teach in a high school, in the field of biology, and is not a candidate for graduation as of the department of botany or zoology. The training needed by the individual lies therefore in those parts and features of biology which will be of service in the class work later to be undertaken, rather than a complete examination of the field as is desirable for a specialist in one line. Yet there should be a guard against "skimming" of the field when it is recognized as greater than can be completely covered. Selection of material to be considered, thorough treatment of this portion of the field in its relation to the rest and as experience in methods of scientific work, and the principles underlying behavior, distribution, injurious association, and mutual dependence of living forms will give sufficient scope for serious work. The final term of the course is devoted to the problem of presentation of the science to high school pupils, and its success may be considered (for the moment) to be closely related to the degree of skill and ability acquired in practice periods by the prospective teacher, now nearly ready for appointment.

In the curriculum list of subjects, it is suggested that botany and zoology be in the form of projects, when forming the definite study of plants and animals. This term is to be considered in a broad sense, and may often be equivalent to "problems" in strict usage. The idea is to have less of text book study, and more of development of personal interest than is possible under the older methods of presentation. The teacher may well guide the interests of the children in the elementary school, or the pupils of the high school into channels which her knowledge of the field indicates may be productive of interests and results, but in the problem and project method she is careful in setting a task for the class without first developing a group interest in the matter at hand, and then encourages distribution of suitable details among the pupils for individual report.

The following suggestions may serve to bring this point into contrast with older methods of treatment of the same general subjects. Every one probably, knows the common lawn weed, called the dandelion, but how many know any definite details about it?

SUGGESTION FOR USE OF THE COMMON "DANDELION" FOR CLASS PROJECT OR PROBLEM.

A. Why is it so hard to get rid of this plant when present in the lawn?
Points to investigate and study:

- a. Vitality; ability to survive mutilation by lawn mowers, weeding knives.
- b. Hardiness; resistance to injury by frosts, by animals' feet, or from feeding.
- c. Adaptation; rosette grouping of leaves checks growth of grass near flowers.
- d. Abundance; repeated blooming of single plant results in quantities of seed.
- e. Distribution; wind scattering of plumed seed assures some in favorable spot.
- f. Resistance; deep penetration of soil by tap root secures needed water.

Many of these details will be found discussed in brief form in one or another of many texts, but the whole series is not likely to be located in any one source of information; at the same time, several of the details may be worked out by the pupils by their own efforts, and their results be compared with published articles (texts) on the same points.

B. How did the name come to be applied to the plant? Is there any reason? This would appeal to a different type of student perhaps from the first.

- a. Who gave the name "dandelion" to any plant? Is this the same kind?
- b. When was the plant named? Were other plants named similarly then?
- c. Why do we have names for plants and animals? What use are they?
- d. Were the same details noticed by the early namers of plants as by later?
- e. Which descriptions tell most about the appearance of the plant itself?
- f. Have all the plants growing wild been named? Why not?

These points will suggest others concerning the art of nomenclature as practiced by the old writers, and will bring out a number of details of definite value which may be applied to other subjects also. Because of the valuable aid in reach in a city library, this topic might serve especially in a big city class, when actual specimens for class use might be insufficient for best results.

A project which was successfully carried out by a high school class, is reported in Stevenson, *The Project Method of Teaching*, p. 258. The relation of rust on wheat to the yield of grain, and the share of barberry bushes in distribution of rust to the wheat, was called to the attention of pupils in Urbana, Ills. They organized a committee of inspection for the town, discovered an abundance of rust on the wheat about the region, and the alternate stage upon barberry bushes in dooryards and parks in the city itself. Friendly interest, and public sentiment resulted in the destruction of many of the bushes, and a general clean up that was regarded as definitely helpful. (This was during the world war needs.)

CONCLUSION.

The training of a teacher for work in biology in an average high school should include the usual work in psychology and theory of instruction, required of students in Normal training schools generally as a foundation for their work. The general subjects like composition and literature can be covered by suitable selections from scientific writers, especially those whose work has been largely in the field, and therefore descriptive of conditions of life and forms of plants and animals characteristic of different regions. Biology is the final one of the subjects in science in this curriculum, since biology itself includes details from the other sciences to a large degree, if carefully followed through. The important attitude to be developed on the part of the young teacher is the broad character of his field, the contacts with other sciences, the fundamental nature of this science as to human progress, and the balance developed by nature among the varied forms of life in any region which when disturbed often works serious damage to human enterprises. With these, and related points as background the technical skill for instruction is to be gained by practice under supervision and discussion, to the point of successful performance.

In the course suggested above the titles could have been shown in three groups, according to their share in the training of the prospective teacher, as follows:

Psychology-Education
Introduction to Teaching
Principles of Education
Psychology of Adolescence
Advanced Educational Psychology
Educational History of U. S.
Principles of Teaching, Sec. Sch.
Principles of Science Teaching
Practice in Art of Teaching

General Education
English Composition
Oral English
Essays and Biographies
European History
Economic History of U. S.
Political Economy (Civics)
Commercial Geography
Sociology

Technical Training
General Science
General Biology
General Physiology
Physical Geography
Agriculture, Essentials
Biology, Special Economic
History of Biology
Projects and Problems

The first group pertains to the development of a "trained teacher" for any field; the second are "good citizenship" subjects, giving broad social contacts to the individual; the third comprise the topics directly related to the special field of education in which the teacher's work is to lie, and all these unite for the development of the final product—a teacher trained to teach biology.

A BRIEF BIBLIOGRAPHY ON TEACHING METHODS. SUBJECT MATTER TEXTS ARE NOT INCLUDED IN THE LIST.

BRICKER, G. A. *The Teaching of Agriculture in High Schools*. Macmillan Co. 1921. Chap. viii gives manner of presentation of subjects under the newer conditions, and discusses possibilities and limitations of the project or problem method in science.

- CHILDS, H. G., GRAY, W. S.; MEAD, A. R. *Bulletin 29, 1917, U. S. Bureau of Education*. "Results of Practice Teaching on the Teacher;" "Results of Practice Teaching on the Pupils;" "Practice Teaching for Teachers in Secondary Schools." Three valuable discussions.
- DEWEY, JOHN and others. *Creative Intelligence*. Henry Holt & Co. 1917. Pp. 176-227 give an historical discussion of the development of scientific thought in contrast to other types of mental activity; "Scientific Method and Individual Thinker."
- CLEMENT, JOHN A. *Curriculum Making in Secondary Schools*. Henry Holt & Co. 1925. Chap. xv., "Reconstructed Science;" a review and summary of results following from the readjustment of science instruction to the newer modes of teaching.
- EIKENBERRY, W. L. *Teaching of Science*. Univ. Chicago Press. 1922. Considers subject matter, pupil and teacher as a triangle of interests in the project method of instruction; problems in biology receive definite attention.
- EIKENBERRY, W. L. *Problems in Botany*. Ginn & Co., 1924. Definitely planned to meet the need of assistance among teachers in secondary schools in the field of plant study. Probably as useful as any single book here noted.
- GANONG, W. F. *The Teaching Botanist*. Macmillan Co. 1899. One of the first definitely teacher-aiding books, which is of so general value to retain much of its original usefulness; principles are emphasized, both as to the plant life studied and the methods of instruction most successful with students.
- HUNTER, G. W. *The Place of Science in the Secondary School*. School Review, June, 1925. Discusses the change in relative importance of several sciences during fifteen years, as affected by pupil enrollment and school offerings. (Collateral and historical.)
- JUDD, C. H. *Psychology of High School Subjects*. Ginn and Co. 1924. Chap. xiv discusses Science by contrast with other subjects in reference to the mental activities involved in teaching and in learning. Sciences not specified separately.
- LLOYD AND BIGELOW. *Teaching of Biology*. Longmans Green & Co. 1907. One of the standard books for teachers, giving separately methods and suggestions as to materials for teaching Botany and Zoology to High School, or Junior College classes.
- MILLIS, W. A. AND H. H. *Teaching of High School Subjects*. The Century Co. 1925. Chap. xi gives helpful contrasts between subject matter and methods in the Humanities and Sciences while Chapter xv is devoted to Biology, as to objectives, methods, values.
- MINOR, RUBY. *Principles of Teaching Practically Applied*. Houghton, Mifflin & Co. 1924.
- STEVENSON, JOHN A. *The Project Method of Teaching*. Macmillan and Co. 1925.
- TRAFTON, G. H. *The Teaching of Science*. Houghton Mifflin & Co. 1918.
- TWISS, G. R. *Principles of Science Teaching*. Macmillan Co. 1922.
- These four volumes devote definite chapters to the subject of biology and its particular difficulties. They advocate the use of the project or problem method in class work, and offer suggestive examples of such exercises actually carried out. Minor and Stevenson are especially good on this point. Twiss is especially helpful for bibliography.
- NUTT, H. W. *Principles of Teaching High School Pupils*. Century Co. 1924. The psychology of the High School pupil is discussed in a manner which makes this a valuable companion volume for the group of four just named which give matter and method while Nutt gives mental attitude of teacher and pupil under successful procedure.

RESEARCH IN PHYSICS.

CONDUCTED BY HARVEY C. ROYS,

University of Oklahoma, Representing the American Physical Society.

The present plan of carrying on the work of this department is to get physicists to write on subjects which are of special interest to them either thru their own research or thru a careful following of the work of others. That the American Physical Society is definitely interested in helping science teachers is evidenced by the following letter which has recently been sent to all members of the Society:

THE AMERICAN PHYSICAL SOCIETY.*To the Members of The American Physical Society:*

The Council and the Educational Committee of the American Physical Society have for some time been considering methods for bringing the high school teachers and other teachers of physics in the smaller colleges into closer touch with the methods and spirit of modern physics. The high degree of specialization which has developed in many of the branches of physics threatens those not actually engaged in research work with loss of contact with the newer developments.

Various methods have been considered for accomplishing this end, such as the publication of another journal besides the *Physical Review*, devoted especially to the needs of the teacher, and the foundation of an auxiliary society, but for the present at least none of these seem practicable or desirable.

It is believed that the situation can be remedied only by the serious efforts of a large number of members of the Society. Hence the Council appeals to the members to help in this important cause. The following measures are suggested:

1. There is a definite need to get before the teachers in high schools and colleges such things as (a) relatively simple digests of research work, (b) semipopular explanations of recent developments, (c) discussions of demonstration and laboratory experiments, and (d) suggestions of simple experimental problems that would lead to explanations of simple and well-known phenomena. The Editor of *SCHOOL SCIENCE AND MATHEMATICS*, 5517 Cornell Avenue, Chicago, is eager to publish papers of the above character. He has asked the Society for cooperation and has selected a member of the Society, Dr. H. C. Roys, University of Oklahoma, as his department editor in charge of research in physics. The Council urges the members of the Society to cooperate with this journal and similar journals in the publication of much needed articles. From an educational point of view, this is worth much of their time and energy. Members should not be too diffident about sending in material because of a fear that it does not contain new ideas. The probabilities are that it will be new and interesting to many of the readers. Suggestions for articles will also be of great assistance.

2. The Council and Educational Committee believe that there is much to be gained by the formation of a large number of organizations of teachers of physics. The Council hopes that each member of the Society will consider carefully the possibility and advisability of the organization of a club in his vicinity. The precise nature of the club and the extent of its territory should depend on local conditions.

In several cases the formation of state clubs has proved to be very helpful. In the vicinity of several large universities teachers have been organized, resulting in a greatly increased cooperation. A number of these teachers have taken up graduate work and in some cases research work. It has apparently increased the number of students majoring in physics. Kindly advise the Secretary in case there is now such a local club in your vicinity.

The Council believes that the major purpose of the Society will be greatly advanced by the cooperation of the members in assisting in these two movements. The need of your cooperation has not been unduly stressed. We have neglected these matters too long.

Respectfully yours,

HAROLD W. WEBB,
Secretary.

March 1, 1926

NOVEL U. S. FARM RADIO SERVICE TO BLANKET NATION.

The new radio service of the United States Department of Agriculture, organized by Sam Pickard, Chief of Radio, includes three novel farm features, all departures from customary methods of presenting information by radio.

The "Farm News Digest" started February 1, and available bi-weekly to all radio broadcasting stations requesting it, consists of short items of agricultural news selected from several hundred current publications, most of which are not accessible to the average farm reader.

"Fifty Farm Flashes," a daily service consisting of fifty timely, practical questions put by farmers and tersely answered by agricultural authorities, will be put into the air by approximately twenty broadcasting stations, starting February 15. Stations will be furnished only such material as is of particular interest to their respective agricultural sections. The various divisions of the service are released at any time between 12:30 and 1:30 p. m. on the following days: Monday—Livestock; Tuesday—crops and soils; Wednesday—Poultry; Thursday—fruits and vegetables; Friday—dairying.

For the women of the household a "Housekeeper's Half Hour" will be on the air from a large group of stations after February 15. An informal, chatty program, both inspirational and informational, is planned to present attractively the great fund of facts of interest to homemakers, resulting from research conducted by the department. The greater part of this material will originate with the Bureau of Home Economics. However, almost every bureau in the Department of Agriculture has done work of direct or indirect benefit to women, and this information will be available. "Questions Women are Asking," "What Shall I Have for Dinner?" and "Today's Pick of Recipes" are the three dominating features of the program.

The Radio Order of Junior Gardners will be started by the department March 1. Stations using this service will introduce the character "Uncle Bert, the Garden Expert." The gardening authorities of the Department of Agriculture put their information into his mouth. Timely gardening subjects will be discussed in dialogue fashion, one or more boys or girls at the microphone asking questions. The dialogue, which will last about 15 minutes, will be released on various days during the week by the different stations. Boys and girls who enroll in the club by writing the department will be furnished copies of Uncle Bert's talks and supplementary gardening material in printed form. The garden club will be followed later in the year by similar organizations covering other nature studies.—
[U. S. Department of Agriculture.]

PROBLEMS IN THE TEACHING OF JUNIOR HIGH SCHOOL MATHEMATICS.

BY CHAS. H. BUTLER,

University of Missouri, Columbia, Mo.

Last summer, while conducting a course in the Teaching of Junior High School Mathematics, the writer took occasion to institute an inquiry concerning the difficulties and problem situations which the Junior High School mathematics teacher encounters. Practically all of the members of the class were experienced teachers actively engaged in teaching mathematics in Junior High Schools in Missouri. These teachers were asked to make lists of the particular teaching problems or difficulties which they actually encountered in teaching Junior High School mathematics. Wherever possible, these were put in the form of questions in order to avoid ambiguity and misinterpretation.

After these separate lists had been submitted they were thrown together into the composite list which forms the basis and body of this report. It is presented without any significant deletion. It is not offered with the idea of answering the questions and solving the difficulties, but in the belief that it may serve to focus the attention of its readers upon some of the problems which the mathematics teacher actually does face in her work, and stimulate constructive thinking in the direction of their solution.

It was not easy to group and classify all the items which were submitted, and the attempt has not been entirely satisfactory. The lists were first examined and arbitrary classifications were set up. These were subsequently revised, and the four-fold classification which was finally evolved is presented herewith:

I. GENERAL METHODOLOGY.

- 1—How can the work in Junior High School mathematics be correlated to best advantage with the work in other subjects?
- 2—How can pupils be made to feel a real need for mathematics?
- 3—How can pupils be made to understand and appreciate the objectives of the work in mathematics?
- 4—How can the particular mathematical needs of the class be discovered?
- 5—Where, other than in the textbook, can the teacher find proper supplementary material to meet the needs of the particular class being taught?
- 6—How shall the teacher determine the relative emphasis to be placed upon the various parts of the work?
- 7—How shall the teacher present each new topic or unit of work to the class most effectively and economically?
- 8—How, in the same class, can the teacher reconcile the claims of the prospective college students and of those pupils who probably will never go to college?
- 9—What should be the ratio of the amount of work done in class to that done outside of class time?

10—How shall time be apportioned among the various units or topics in the course?

11—In case circumstances make it advisable or necessary to eliminate some parts of the course, how shall the teacher determine what parts are of relatively least value to the class?

12—How can the teacher wisely judge the relative merits of textbooks?

13—How much project work should be included in the course?

14—How should project work in mathematics be planned and conducted?

15—How can the teacher plan a constructive testing program?

16—What kinds of tests should be used and how should they be constructed?

17—What emphasis should be placed on learning and using rules and definitions, and how should these be taught?

II. PREVIOUS TRAINING AND INDIVIDUAL DIFFERENCES.

1—The teacher sometimes has to combat the tendency on the part of pupils toward loose and slipshod methods and habits of work and thinking which may be allowed in some other classes. How can this best be done?

2—What is to be done with the capable, but lazy or indifferent, pupil?

3—What is to be done with the pupil who cannot do the normal work of first-year algebra, and is manifestly incapable of going on with any more advanced courses in mathematics, but who is still required to take the course?

4—What treatment shall be given to the pupil who, through drill, has acquired excellent manipulative skill, but who has much difficulty in reasoning through a verbal problem and in setting up an original mathematical expression for the situation?

5—What is to be done in the case of a pupil who has decided mathematical ability and interest but a poor mathematical foundation upon which to build?

6—Some pupils can solve problems of normal difficulty but are unable to explain the route by which they arrive at their solutions. How can they be trained to analyze and generalize their work?

7—What is to be done with pupils whose work is haphazard and inconsistent?

8—What is to be done in the case of pupils who, through illness or other unavoidable reasons, have missed a considerable part of the work of the course?

9—What is the teacher to do with those few pupils who are decidedly superior to all the rest of the class?

III. ATTITUDE OF PUPILS.

1—How can the teacher overcome the antagonistic attitude of pupils who are taking algebra because it is required and not because they have any interest in it?

2—How can the teacher overcome the idea on the part of some pupils that mathematics is a subject to be avoided if possible, and to be neglected if it is impossible to avoid it?

3—How can the teacher make the subject seem vital and interesting and really related to the things in which the pupils are interested and with which they are familiar?

4—How can the teacher convince her pupils that the study of mathematics is not merely a waste of time?

5—How shall the teacher deal with pupils who have got the notion that mathematics is too hard for them, and who consequently will not put forth any effort toward mastering it?

6—How can the teacher change the viewpoint of pupils who cannot see that mathematics will be of any use to them after they are out of school?

IV. TECHNIQUE OF INSTRUCTION AND MANAGEMENT.

1—It is sometimes hard for the teacher to keep from wanting to require her own pet proofs or methods, and to admit the good points of

other proofs or methods that may be advanced. How can she best overcome this difficulty?

2—To what extent should originality be encouraged in pupils' work?

3—Is it ever wise to insist upon a particular method or device being used, even if it involves the discarding of original methods or devices proposed by the pupils? If so, in what cases?

4—How much, and in what ways, should fast pupils be allowed to hold the slower ones?

5—Should the teacher keep a detailed record of each bit of work done by each pupil? If so, how may this be done without overburdening the teacher with bookkeeping?

6—What are the essential principles of planning field trips and project work in connection with mathematics?

7—How much and what kind of work should be assigned for out-of-class preparation?

8—What should be the bases for grading pupils and assigning marks?

9—Should credit be allowed for late work?

10—Should work be accepted at all if it is late?

11—What credit, if any, should be deducted for lack of care in form, neatness, etc., in written work?

12—What credit, if any, should be allowed for problems worked partially right?

13—What credit, if any, should be allowed for problems worked by the right method but having the wrong answer?

14—Is the granting of partial credit conducive to mental laziness on the part of the pupil?

15—Is the teacher *ever* justified in granting partial credit for a piece of work?

16—Should the teacher require that all problems incorrectly or incompletely worked be corrected or completed and returned by the pupil before credit is granted?

17—Should pupils be allowed to use answer books?

18—What shall the teacher do with a class in which different pupils are interested in different kinds of problems?

19—What can the teacher do to prevent strong pupils or parents from doing the assigned work of the weaker pupils for them, and to secure independent study by all pupils?

20—How can the classwork be made to take care of the problem of discipline?

21—What should be done in the case of pupils who continue to come to class with their assigned work unprepared?

The foregoing list of problems and difficulties is, of course, only the merest beginning of anything like a comprehensive enumeration of the perplexing situations for which a teacher of Junior High School mathematics will need to seek a solution. In spite of the incompleteness of the list, however, the writer has found it helpful in supervision and suggestive of problems that would justify careful research. An extension of the list would add to its usefulness and would be distinctly worth while.

A tourist lunch room at the state park at Interlochen, Mich., was maintained last summer by Michigan State College to demonstrate what can be accomplished by cooperation. The State highway department built an attractive log cabin, near-by farmers supplied fresh vegetables under an arrangement with the agricultural department of the college, and teachers and students from the home economics department prepared and served wholesome meals to tourists visiting the park.

DYES.

BY BERNARD JAFFE,¹ M.A.,*Jamaica High School, Jamaica, L. I.*

Perhaps in no other branch of the physical sciences is there so much romance to be found as in the science of chemistry. Pick up any book which has been written on the men who have raised the science from the black magic of the alchemists to the chemistry which today is penetrating into the hidden corners of the atom itself, and you will find miracles which excel the tales of Aladdin and his lamp, mysteries which eclipse those of Sherlock Holmes, and romances which rival the search for the Holy Grail.

The chemist, buried away in his smelly laboratory, is not the hermit which we sometimes picture, but the practical dreamer and creator rivalling nature herself in his work. Out of his cramped sanctum have come boons that have enriched mankind. The world owes as much to the chemist as to any other group of men who have worked to unravel nature's secrets.

And of all the manifold realms which the chemist has traversed I believe that his role in the field of that part of organic chemistry which touches dye-stuffs is richer in romance and mystery than any other. Until only a few decades ago man depended for his colors upon a few scant pigments found in nature. Today the chemist rivals nature in his display of colors and even outstrips her. The chemist boasts of an array of colors that run the length of the spectrum-colors which are faster and brighter.

The subject of dyes is so vast and complicated that to try to discuss it even in part would find me totally unfit and if I were by some necromancy transformed into the master chemist, it would find you in a state of mental exhaustion at the end of a short time. What I shall attempt is to give you a bird's eye view of the subject of dyes more for the purpose of giving you a glimpse behind the veil.

From the very earliest times man used coloring materials for various purposes. The art of dyeing dates from prehistoric times. China, India, Persia, and Egypt carried out dyeing operations, as the clothes of their mummies show the use of indigo and madder. In prehistoric times the savage covered his body with pigments, later as civilization came, buildings, clothing

¹Lecture delivered before the Jamaica High School Science Club.

and domestic articles were adorned, and today Fashion is sending some of us back to savagery.

Previous to the middle of the last century all the materials used as coloring agents were of natural origin. They were chiefly obtained from (1) colored ores or clays, (2) various portions of plants and animals. Let us first consider some of these as they are comparatively simple to understand.

Among the mineral colors or pigments we include:

1. The various yellow ochers found in all parts of the world, as hydrated ferric oxide mixed with clay. This yellow pigment was used on Egyptian tombs. The Aztecs and Indians used it in abundance.
2. Indian reds are iron ores chiefly peroxide of iron.
3. Red lead or Pb_3O_4 .
4. Khaki made by mixing iron oxide and green chromium oxide.
5. Yellow lead or $PbCrO_4$.
6. Prussian and Turnbills blue.
7. Kings yellow or As_2O_3 .
8. Cadmium sulphide.

Among the natural animal colors may be included:

1. Tyrian purple, a dye extracted from the bodies of a species of shell fish found in the Mediterranean Sea, and of such great importance to the Romans who when "born to the purple" could afford to pay what corresponds to about \$350 per pound for the wool dyed in this color. Today the poorest of us is "born to the purple" for we can make it for a few cents a pound.
2. Carmine, the coloring principle found in the body of a small insect called cochineal, which crawls over the hills of Mexico. For many years the fairest of our fair adorned their faces with the extract of this bug, and beauty was bought by the lives of millions of these lowly insects whose life blood cried out from the lips of the weaker sex. The chemist has come to the aid of suffering humanity and azo dyes made from the much more alluring coal tar have replaced carmine entirely.

Among the natural plant colors may be mentioned:

1. Logwood, a native tree of the Western hemisphere, especially Hayti.
2. Turkey red from the madder plant. This dye has been replaced by the synthetic product called Alizarin made from Anthracene obtained from the destructive distillation of coal. Graebe and Lieberman, two German chemists, filed their patent for its manufacture on June 25, 1867 and the next day Perkin the Englishman, took out his own patent in England. This is one of the most startling examples of scientific results showing how two men working independently of each other solved the same difficult problem within a day of each other.
3. Indigo is one of the world's oldest dyes. Originally it came from India. Twenty-five years ago India had a million acres of indigo plant under cultivation worth \$20,000,000. Ten years ago the acreage fell to 150,000 worth only \$300,000. The story of this change reads like a fairy tale. Germany is said to have spent millions in the search for the structure of the coloring principle of indigo. Dozens of chemists spent years on the problem, and finally in 1882 Adolf von Bayer synthesized it. No wonder it took so long—this is the formula: $C_8H_7COH.NH.C-C.NH.COH.C_6H_5$. He obtained it from naphthalene, one of the products formed in the destructive distillation of coal. Today synthetic indigo has almost displaced the natural color.

The real color industry began about seventy years ago with the discovery of Mauveine, in 1856. In 1838 a lad named William Henry Perkin was born and fifteen years later he entered the

Royal College of Chemistry in London. At the age of seventeen he began research work in chemistry under his German teacher Hoffman. While trying to make quinine from aniline he stumbled across the first coal tar dye. In the manufacture of organic dyes a considerable number of products obtained from coal tar are used as raw materials and it is for this reason that these dyes are called coal tar dyes. A few years later Verguin discovered aniline red. The remarkable discovery of this new industry almost exclusively by English and French chemists was hampered in its development by the complexity of the reactions involved. The adoption of the theories of valency, radicals and structural formulas gave the development of organic chemistry such an impetus that no parallel exists in the history of any other science. Unfortunately these theories made little headway in France and England. In Germany the application of these new views by such men as Kekule, Hoffman, V. Meyer, Graebe, Lieberman, Baeyer, and Liebig brought the industry across the border where it developed rapidly. This has been treated as proof of the superior natural genius of the Germans. It proves nothing of the sort. The German government was behind its chemists while the British government gave the discoverer of Mauve a title but no support in his endeavors to develop the industry. Before the war England had 35 dye chemists and Germany 350.

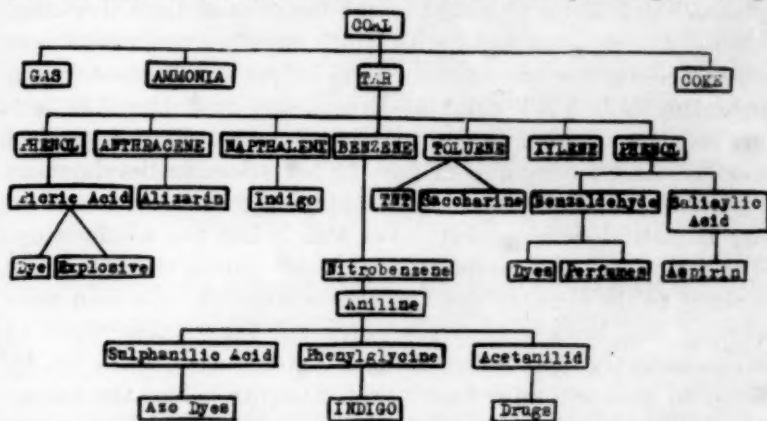
Let us now see how one of the simpler of these coal tar dyes is made. There is a mistaken idea among people that coal tar is a magic mess which contains all the dyes, drugs, and perfumes that are needed by man, and the chemist has only to wave his magic wand over it to obtain them. Nothing could be further from the truth. Coal is the quintessence of the primeval forest. But before we can extract its wonders we must subject it to changes which stagger the imagination of the uninitiated. Look at the chart. The tar used for dyes is only about 0.3 per cent of the weight of the coal.

The chart shows at a glance how closely related are the dye, drug, perfume, and explosive industries. As an example take picric acid. This has been used as dye, explosive, and disinfectant. In close conjunction with the dye industry has been the development of the synthetic aromatics from coal tar. Newmown-hay discovered by Perkin, oil of wintergreen, vanillin, oil of bitter almonds, and dozens of others have been prepared in the laboratory.

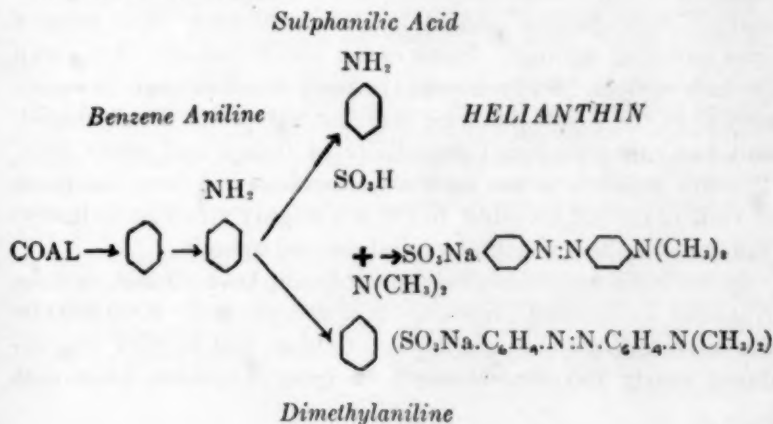
The production of an azo dye includes three operations:

1. diazotization of the primary amine of the aromatic series,
2. coupling with an amine or phenol,
3. precipitation of the dye.

Preparation of Helianthin: Dissolve 10 grams sulphanilic acid (dried) in a solution of 3.5 g of dehydrated Na_2CO_3 in 150 cc water and treat with a solution of 4.2 g NaNO_2 in 20 cc water. To this cooled mixture add HCl solution corresponding to 2.5 g



anhydrous HCl. Before diazotization of the sulphanilic acid prepare a solution of 7 g diamethyl aniline in 25 cc water, and with stirring add a small quantity of concentrated HCl until fuchsine paper is decolorized (or congo paper changes from red to blue). The dimethyl-aniline-HCl thus obtained is added to the diazo solution and the mixture made distinctly alkaline by the addition of not too much caustic soda solution. The dye separates out directly.



Now just a few words on the importance of the dye industry to the world and especially to us. The world war taught us the perils that confronted a nation with an undeveloped dye industry. In a book called "The Riddle of the Rhine" Lefebure tells us why Germany led the world in the production of dyestuffs.

"Germany knew that the organic chemical industry is the type of peace time industry which is par excellence that which can rapidly and silently mobilize for war. Explosives demanded plants which already existed in the factories of their dye combines. The unusual speed with which standard dye works were converted for the production of explosives is instanced in the operation of a TNT plant at Leverkusen producing 350 tons per month. The conversion took but 6 weeks. Germany owed her chemical monopolies in part to her scientific development fostered by a vigorous policy of applying scientific research to her industrial development. Yet this is not the whole story. The American alien property custodians during the war made a study of the German dye agencies in America. German price cutting and bribery of dyers prevented the establishment of a dye industry here. Thousands of patents were taken out by them to cramp competitors. Prof. Stieglitz before the Senate Committee in 1920 said, "I have come to the conclusion that we would have saved a great deal of suffering and a great many lives if we had an organic chemical industry like Germany's."

Besides this war danger there was an industrial danger. When the war broke out in 1914 this country began to realize what it meant to be at the mercy of a foreign monopoly. The Scotch Highlander was not the only one who depended for his dyes on Germany. He had to use smuggled dyes to color his kilts. America in 1914 imported about 6,000 different dyes from Germany. We ourselves made only about 100 dyes. The price of dyes mounted sky high. Some of our textile factories shut down for lack of dyes. So great was the need of colors that Germany sent over the first submarine merchant ship, the *Deutschland*, and her cargo consisted essentially of indigo and other dyes. The dye industry is not such a tremendous one from the point of view of capital invested, but it is a mighty strategic industry. Billions of dollars worth of capital depend upon it.

In 1917 the American government finally took a hand, and the National Aniline and Chemical Co. was organized. \$200,000,000 was invested in the manufacture of colors and in 1917 we produced nearly \$60,000,000 worth of dyes. Chemists knew that

when the war ended Germany would throttle this infant industry. So to protect it Congress was finally forced to place a duty on imported dyestuffs. Whether the American industry can really compete with the foreign in an open market is a question, but something else was done which makes us independent even of the tariff. A few years ago the 4,500 German chemical patents seized during the war by the alien property custodian were sold by him to the Chemical Foundation for a quarter of a million dollars. This foundation was organized as an association for the advancement of the chemical industry in America and undertook to manufacture dyes. Whether this has solved the old problem is still doubtful. When Germany gets on her feet again perhaps there will be another story to tell. Or perhaps America has learned her lesson, and will permit herself no longer to become dependent upon a foreign country for her essential chemicals.

TEST SHOWS WOMEN MORE IRRITABLE THAN MEN.

That women are more irritable than men has been generally admitted, but a woman physiologist has now brought definite proof that this is so. Miss Emily Williams of the University of Illinois proved it by means of the knee-jerk test on 63 men and 70 women. This test, Miss Williams said, is considered a reliable index to the general body tone and irritability.

The women proved to be the highest kickers, it was found, and exceeded the men by 42 per cent in the distance kicked. When a sharp blow of a little less than 2 ounces was applied to the knee ligament, the men kicked to an average height of not quite 14 inches but the women to more than 19 inches. The men, however, were more irregular, for both the highest and lowest kickers were found among them. The knee-jerk was absent in men much more frequently than in women.

"The knee-jerk is now used to diagnose injuries to the spinal cord," Miss Williams explained. "In the disease known as locomotor ataxia certain nerve tracts are injured and the jerk is lessened or lost altogether, depending on the severity of the disease. The same is true in infantile paralysis. According to the results of various investigators, practically any variation in the general bodily tone or irritability will be shown in the knee-jerk.

"One investigator found that the jerk was affected by exercise, cold baths, food, music and mental activity. Another observed that hunger greatly increased the response. Two others, in studying the factors which increase and lessen the knee-jerk, noticed that any painful stimulation of the nerves as by pinching, burning, freezing, electric shock, or exposure of the eyes to the glare of a burning magnesium wire increased the distance of the kick.

"In this experiment," Miss Williams continued, "college students between the ages of 18 and 24 were used and all the tests were made on normal subjects under similar conditions. A uniform blow of 50 grams, or less than 2 ounces, was insured by means of a simple machine. Each subject registered about 100 kicks, and the results showed that women are definitely more irritable than men."—*Science Service*.

AN EXPERIMENT IN THE TEACHING OF PHYSICS.

BY EUSTACE BROOM,

San Diego, Calif.

There seems to have developed during past years a routine plan for the teaching of high school science courses. This plan is based upon textbook instruction for three periods of from forty to forty-five minutes per week and upon laboratory experimentation for two periods of from eighty to ninety minutes per week. It is probably the result of a too heavy teaching load placed upon the science teacher, especially in the small high school, complicated with a lack of sufficient equipment for a course in experimental science.

It has seemed to the writer as he observed the conduct of classroom work in physics, particularly, that this method of instruction did not economize the students' time, and that it was responsible for financial waste as well, since to it might be traced numerous pupil failures. It seemed that there should be some better basis for planning lessons and for executing class teaching.

An opportunity offered during the present school year to conduct an experiment in the teaching of physics in other than the conventional method. The writer is conducting a class which is being taught by a method which combines features of the project method and supervised study. There is nothing especially original to the writer in this plan. Under this plan the project method is merely a teaching device which leads the pupil to attack a lesson unit in the same sensible way that he would use in attacking a problem undertaken at his own behest when he is pressed by a felt need or desire. This statement implies something broader and more adaptable than simply presenting and working out the projects of others into which the student has been drawn. It simply means an arrangement of the assignment in such a manner that the pupil must attack the lesson unit as he would attack a project.

¹Textbooks in use follow. Each student reads in at least two textbooks for each assignment. Carhart, H. S. and Chute, H. N. *Practical Physics*. New York: Allyn and Bacon, 1920. 502 plus 9 pages.

Fuller, R. W., Brownlee, R. B., and Baker, D. L. *Elementary Principles of Physics*. New York: Allyn and Bacon, 1924. 859 plus 15 pages.

Henderson, W. D. *Physics in Everyday Life*. Chicago: Lyons and Carnahan, 1925. 573 pages.

Hoadley, G. A. *Essentials of Physics*. New York: American Book Company, 1921. 544 pages.

Millikan, R. A., Gale, H. G., and Pyle, W. R. *Practical Physics*. Boston: Ginn and Company, 1920. 461 pages.

Laboratory exercises are taken from a number of textbooks and presented to the students in mimeographed form. The following manual, however, is very frequently used.

Fuller, R. W., and Brownlee, R. B., *Laboratory Exercises to Accompany Carhart and Chute's Physics*. New York: Allyn and Bacon, 1913. 315 pages.

In the present experiment this is undertaken by means of mimeographed assignment sheets which include references to the textbooks in use,¹ assignments to the laboratory manual in use with partner assignments given if any are necessary, assignments for special pupil reports, and a list of questions and problems for the guidance of the pupil in his study. The questions are so designed that a thorough knowledge of the text material is necessary before they can be answered.

After he has received his quiz sheet, the student is free to study at his own leisure, to set up for himself the demonstration experiments given in the textbook which he studies, and to work out the laboratory problems assigned in connection with the quiz sheet. This routine is occasionally varied by occasional lecture sections, generally used when a new subject is introduced or when some group of students is in difficulties, by group discussion or quiz sections, by written examinations and standardized tests which are applied to test the knowledge gained by the students, and by field trips and observation work. The class periods used are ninety minutes in length daily. This allows sufficient time for the students to complete most of their work during the class time.

Three rooms are used for the work of this class. In the laboratory proper conversation is permitted. Here all the experimental work is conducted. The laboratory darkroom is used for a study hall and here absolute quiet is required. The laboratory office which is small is used for individual recitations which must always be given for each quiz sheet. The student elects his own time for recitation, and frequently two may recite at the same time. It is not necessary to quiz the student over the entire assignment. The writer has used the method of asking a few questions covering the important items of the assignment and then permitting the student to suggest his difficulties. If after the check-up for all students, there seems to be one point of difficulty to the entire group, it has seemed valuable to call a formal meeting of the group to discuss again this one point. Similarly it is possible to review past assignments from time to time with the weaker members of the group without demanding the presence of all members of the class group.

It is obvious that certain students have much more time after completing their assignments than others. This is true because an effort is made to gauge the length of the assignment to the weaker third of the group rather than to the median group. The

special assignments, including frequently the introductory lecture sections, are handled by the more advanced students. Outside references are given them for this purpose. The appeal of the intricate appearing instruments in the physics laboratory helps to take care of the spare time of the advanced students. When a student is freed of responsibility for a quiz sheet by means of completing his assigned work, he can attack a project of his own. The writer has found that much of the experimentation has been aimless and utterly unscientific; yet it seems to arise from an interest in scientific material which may prove the basis for later genuine scientific endeavor. "The scientific attitude of mind is by no means a simple attitude and it is not one readily assumed by the immature thinker."² Furthermore, "science and skill . . . are the most diverse aspects of mental development. It is only in the latter stages of the two that they are brought into productive relation."³

There are some very interesting teacher and pupil reactions to this type of instruction. It is rather difficult at first for the teacher, accustomed to the formal, routine type of instruction, to adapt himself to the informal method. It means constant attention to the business in hand, and it requires a broadness of knowledge which was unnecessary under the old method. The laboratory method on which the success or failure of this experimental method hinges is usually too complex for the immature student to master if left to his own devices. He must be led by short paths to the productive conclusion which science has already reached as its final result. In his own individual experimentation he must be similarly aided in achieving results satisfactory to himself. The student must be called on to find out for himself, and yet he must not be allowed to become confused through trial and error experimentation. The instructor's problem is to determine the proper balance between instruction and independent effort for each student in his group as well as to wean them away from their old ideas of a recitation and reciting.

The reaction of the pupils is marked. They have been accustomed to repeating either verbatim or in thought content the contents of certain assigned paragraphs, often without any idea of the real meaning of the pages. When they are not allowed to proceed in this fashion, but are asked to demonstrate either with

²Judd, page 304.

³Judd, page 304.

laboratory materials or graphically at the blackboard the meaning of an assigned paragraph, many of them are lost at first. When, however, they finally orient themselves and their minds to this type of work, they comprehend all an assignment contains so that they can take advantage of what it says and use it. The pupil learns to attack his problems logically, to think them through to the end, and then to make practical applications of them.

It is early, perhaps, to make any attempt to correlate the results attained by this group with other groups, yet certain results are marked at present. The group is an average group of nine pupils with the usual distribution of ability, gauged upon the instructor's judgment, aided by the reaction of the students to certain exercises taken from the camp physics' scale as compared with similar reactions of other groups in the past. This is, of course, a rough measure. Before any conclusive judgment could be obtained the groups would have to be equated on the basis of intelligence tests, and a control group taught by the routine method. Yet it seems that the students have attained knowledge of facts in mechanics more rapidly and more thoroughly, at the same time penetrating more deeply into the subject in discovering that there are problems to be solved and in seeking to discover solutions for those problems. The writer is not yet ready to recommend it without hesitation, yet it is worth continued observation and experimentation.

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3. McMURRY, C. A. "Teaching by Projects." New York, New York: The MacMillan Company, 1921. Chapter I and page 257.
4. SKINNER, R. W. "The Project Method in Physics and Chemistry." *School Review*, XXX: 533-535. (September, 1922).

A bonus of \$5 is given to each teacher in the public schools of Rochester, Minn., as an expense aid in attending education conventions of the State or division. Attendance of all teachers is required unless excused by the superintendent.

Creation of a junior college as a part of the public school system of Washington, D. C., is contemplated in a joint resolution recently introduced in the Senate of the United States. A similar resolution was introduced simultaneously in the House of Representatives.

INCIDENTAL IMPRESSIONS OF ENGLAND.

BY HARRIET A. STEEPER,

Bradford Academy, Bradford, Mass.

During the year 1924-25 it was my privilege to teach science in the Girls' County School, Bishop Auckland County, Durham, England. It was an exchange as a teacher from the English school came over here to Bradford Academy, an arrangement effected by the English Speaking Union. This organization, originally founded to bind England and her colonies more closely together, has now invited the United States to come in to this English speaking group for purposes of better understanding. Under this management, then, and with a real desire to know the English people, I began work in an English school, a convenient, modern building with fine yard, courts, and gardens.

The Girls' County School had an enrollment of 400 girls coming mostly from the colliery districts and a staff of twenty-one teachers. Unlike Bradford it was a day school and largely financed by the government. The years covered would correspond to two years of Junior High and the years of our regular High School. The girls entered by competitive examination at the age of eleven or twelve years. It was competition too! Out of 450 girls who took the entrance examinations, only seventy could be admitted owing to lack of room, and of the 380 not admitted, very few would have any secondary school education at all. Just as fast as England can, she is building more secondary schools for girls, but she still staggers under the enormous burdens which have resulted from the Great War as does all Europe so that the advancement of secondary education is slow. The girls in the school seemed younger to me than do ours of the same age, perhaps, because they all wear uniforms, very short, dark green tunics and pongee blouses; but they were most industrious and interested in their work. They had to keep their work up to a very good standard or they were asked to depart in order to give their places to some younger, brighter students. In physique these English girls compared well with ours and were very fond of games being able even in the North to play their games out of doors almost all winter.

I taught botany, geography and chemistry to girls in the third form, a year which corresponds to our first year of high school. The headmistress very wisely decided not to give me the little ones nor yet those older ones who were going up for examination.

My work was further safe-guarded by assigning to me classes whose work was exactly paralleled by some other teachers, so that I could have frequent conferences on subject matter and check up on actual progress. There was almost no need of discipline. The older responsible girls of the school called prefects relieved the teachers of much monotonous routine work.

One of the things that impressed me most was the girls' ability to carry so many subjects at one time without confusion. Both the botany and chemistry work consisted of one double period (two forty minute periods) per week and the geography two single periods. The English school year is about forty weeks. On one of the geography days I taught physical geography and on the other the geography of North America. It was most considerate of them to give me North America! Botany was begun in the form I taught and was continued for three years. In these three years the same amount of work was covered as we have to cover in one year using five periods a week. The chemistry had been preceded by physics and domestic science and was followed by hygiene. There was much more geography done than in our schools, in fact, it was taught throughout the entire course. I very much wish that we could have more geography taught in our schools and am thoroughly in sympathy with Prof. Atwood of Clark University in his plea for more geography in our school system.

In conclusion let me say that I have come back feeling that each nation would benefit by borrowing points from our respective systems of education, and that above all else, we need to know each other far better than we do in order to be sympathetically critical and helpfully constructive as both nations go forward in that glorious work, the education of our young people, the future leaders of the English speaking nations.

FEW OREGON BOYS FOLLOW CALLING OF FATHERS.

To determine vocational choices of boys in the ninth grade of the University of Oregon High School, a study was recently made of the occupations of the fathers of these boys and whether they desired to follow the same line of work.

Of the 203 boys tested, 177, or 87.2 per cent, had already reached some conclusion as to their life work; 26, or 12.8 per cent, registered no choice. Of the 177 boys expressing some preference, the largest number, 57, indicated manufacturing and mechanical industries; 54, professional service; 25, agriculture, forestry, and animal husbandry; and 19 chose commerce. Only 39 of the 203 boys, or 19.3 per cent, wished to follow the occupations of their fathers.

CURRICULUM STUDIES ON THE PLACE OF RADIO IN SCHOOL SCIENCE AND INDUSTRIAL ARTS.*

BY EARL R. GLENN,

Department of Natural Sciences, Teachers College, New York,
and

L. A. HERR,†

Industrial Arts, The Lincoln School of Teachers College.

PART 2.—A RADIO PRIMER FOR PUPIL AND TEACHER.

(Continued from April.)

XIII. THE PANEL.

We have found that hard rubber makes the best panel for the beginner. The rubber can be given a dull finish if desired. To do this lay the panel on a flat surface and support it between two thin strips of cigar-box wood nailed to the bench against the ends of the rubber. Sandpaper the surface with fine sandpaper, making the strokes the full length of the panel. Con-

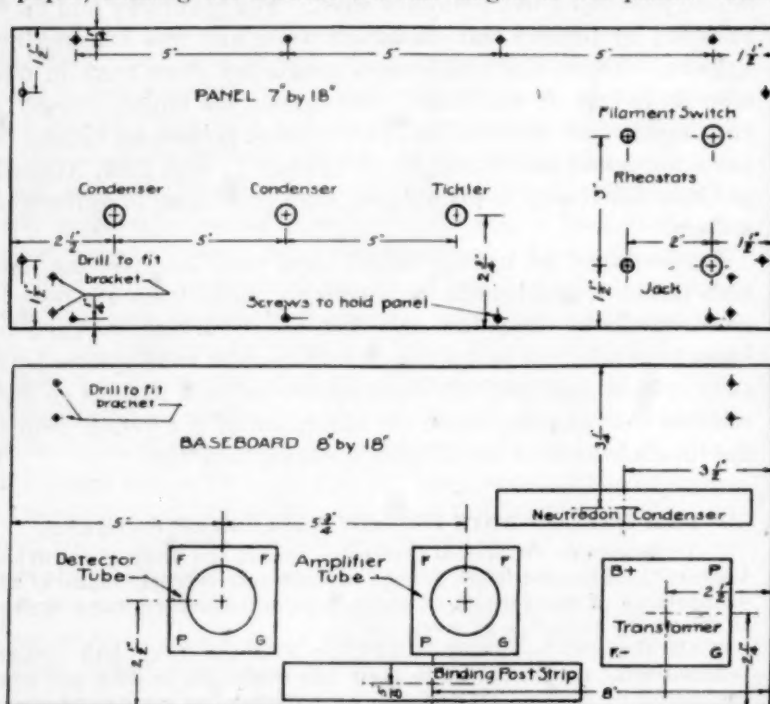


FIG. 43. PANEL AND BASEBOARD PLANS.

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†Practically all of this work was completed while the author was a member of the staff of the Lincoln School.

tinue the sandpapering process until the entire surface appears gray when the sand has been wiped off. Next rub the surface with powdered pumice dipped in oil. Do this rubbing with cotton waste or a piece of cloth. A circular movement may be used in this rubbing. Next wipe the surface clean and free from oil and pumice. This should leave a dull black finish.

The panel layout is illustrated in figure 43. Copy this plan on a piece of paper the exact size of the panel. The wrapper in which the panel is purchased is useful for this purpose. The center holes only of the condensers, rheostats, and other instruments are shown in figure 43. Fit the patterns which come with the instruments so that the center holes will fit the center holes in the panel layout. Next place the panel form over the panel, with the edges exactly even, and mark the center points for all holes with an awl or sharp nail. In doing this be careful to hold the awl, or nail, straight so it will not slide when struck with a hammer. Drill all the holes with a number 27 drill first; to do this lay the panel flat on a smooth board. Next, use the drill needed for the required screw or shaft and enlarge the holes just bored.

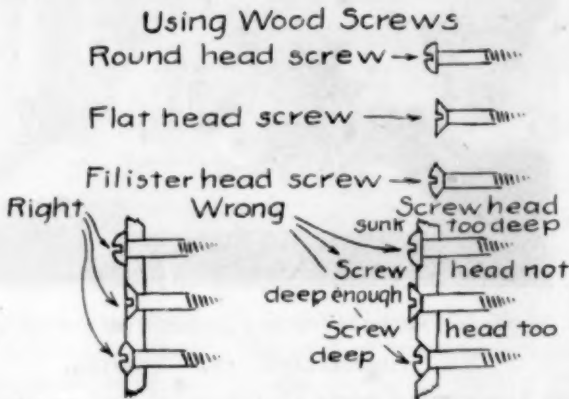


FIG. 44. IMPORTANT POINTS TO WATCH IN BORING AND COUNTER-SINKING SCREW HOLES.

Countersink the holes for screw heads very carefully as illustrated in figure 44. The screws in the panel should not fit the holes tightly; those for shafts should be so large that the shaft will not touch the edge of the hole.

XIV. THE BASEBOARD.

A plan for placing the essential parts on the baseboard is shown in figure 43. This board should be one-half inch thick

and of the size indicated. Its surface should be planed and shellacked. Note that the dimensions indicate only the centers of the parts. When these positions have been determined the pieces should be fastened by means of wood screws.

The grid (G) and plate (P) terminals of the sockets should be placed toward the back as shown in figure 43. The side of the transformer marked G and F (or secondary) should be placed toward the back. The NP and S coils are placed in position after the panel is fastened to the baseboard and the tickler coil has been mounted.

Rotate the tickler coil into a vertical position and mount the NP and S coils so that the centers of the tickler, NP and S coils are along the same horizontal line.

In fastening the panel to the baseboard, bore holes in the wood slightly smaller than the screws to be used and turn the screw slots all in one direction in the finished job.



FIG. 45. OFTEN A FRIEND IS NEEDED TO HELP SOLDER A CONNECTION.

XV. ASSEMBLING AND TESTING.

Fasten the smaller parts to the panel first as these are in least danger of being damaged. First mount the filament switch, then the rheostats, the jack, and the tickler bushing. The variable condensers should be mounted last. In mounting these, keep the movable plates in so they will not be bent when the instrument is handled. It sometimes happens that the screw holes in the panel for the condensers will not fit perfectly. If this occurs, enlarge the holes. The handle end of a file makes a good reamer for doing this. The tickler should be mounted next. When this has been done the panel is ready to be fastened

to the baseboard. The dials should be mounted so that the zero (0) will be at the top when the condenser plates are out. The tickler dial should be set so that 50 will be at the top when the coil is in a horizontal position.

XVI. NOTES ON SOLDERING.

Wires in a radio receiver may be joined by twisting, soldering, or by the use of clips or binding posts. Many connections are best made by soldering and for this work both gas heated and electric soldering irons are used. We have found the electric iron superior to all other types. To do good work the copper tip and wires should be coated with clean solder. It is often necessary to scrape the hot soldering iron and dip it into a cleaning mixture called soldering paste.

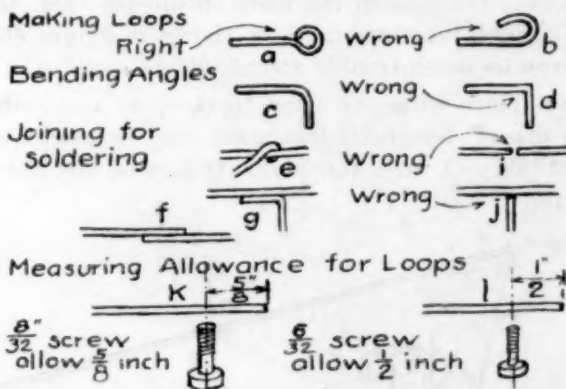


FIG. 46. SOME PRACTICAL WIRING HINTS.

Resin core solder has the resin in the center of the wire and is the best kind of solder to use. We have found that good soldering requires a clean, hot iron, a small amount of solder, and the proper application of heat to the parts to be joined *before* the solder is applied. The ends of wires or terminals to be soldered must be clean. Scrape the metal with a knife or sandpaper. If two clean wires touch each other and are heated by means of the iron placed in contact with both, the wire solder will melt at once when touched to the parts to be joined.

This plan is quite a different procedure from the attempt of many beginners to put "dabs" of solder on cold, dirty wires.

XVII. SOME PRACTICAL WIRING HINTS.

Each wire used in connecting two or more points should be completely bent to its final shape before either end is fastened in place. Begin by making a small loop in case the wire is to be

fastened to a screw. The round-nose pliers are useful for this work. Shape the loop as shown in figure 46a. Next make any necessary bends starting with the one that is nearest the loop. Make the other bends in order, working toward the other terminal. Figure 46c shows how bends should be made. Before the wire is cut an allowance must be made for the second loop. Let the wire extend $\frac{5}{8}$ inch beyond the center of the screw and cut at this point. When the loop is made its center will be at the desired point. Allow $\frac{1}{2}$ inch for loops to fit screws 3-32 inch in diameter. (See figures 46k and 46l).

In soldering ends the wire should be made mechanically strong so that tension or pressure will not come in the solder. See figures 46e and 46f for suggestions. If a hook can not be used to bear the tension the wires should lap (Fig. 46g) about $\frac{1}{2}$ inch. Such junctions as those shown in figures 46i and 46j have given us much trouble and should be avoided.

Do not place wires too close together or run them parallel to each other. Spaghetti insulation may be used where there is a possibility of wires touching. Otherwise the less spaghetti the better.

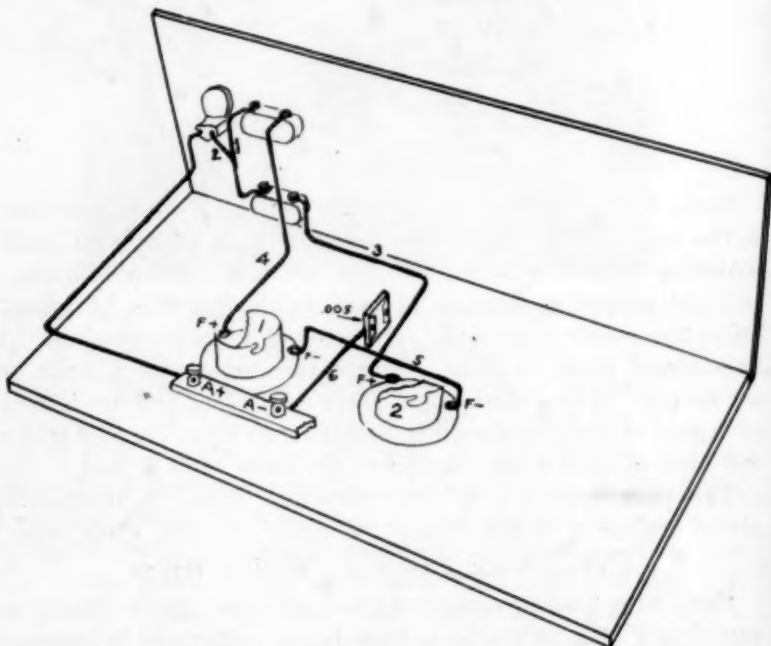


FIG. 47. DIAGRAM FOR WIRING THE A-BATTERY CIRCUIT.

XVIII. WIRING THE A-BATTERY CIRCUIT.

Wire the A-battery circuit as indicated below. Each number refers to a wire shown in figure 47. Make and connect the seven wires as follows:

1. Join the left screws of rheostats, as seen from the back.
2. Connect wire 1 to the switch.
3. Join the right screw of lower rheostat to plus F on tube 2.
4. Connect top screw on top rheostat to plus F on tube 1.
5. Connect minus F on tube 1 to minus F on tube 2.
6. Connect minus A binding post to wire 5. This wire extends on two inches and is joined to one side of the .005 mfd. condenser.
7. Join plus A binding post to switch.

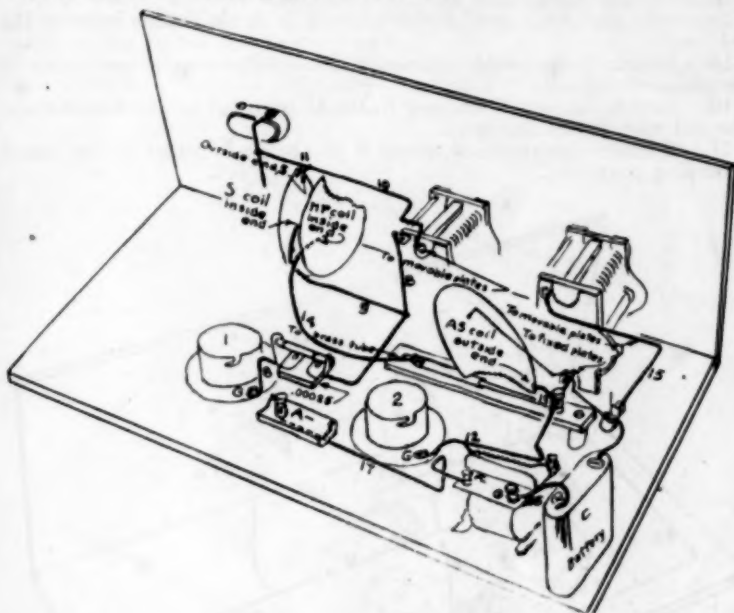


FIG. 48. DIAGRAM FOR WIRING THE GRID CIRCUIT.

When all of these contacts are made test the mechanical strength and accuracy of the connections. Join the plus A of the battery to the plus A binding post and minus A of the battery to the minus A binding post (See Fig. 51). Place a good tube in a socket. Close the switch, and turn on the rheostat. If the tube lights repeat this process with the tube in the other socket. Then try both tubes at one time. Check the wiring carefully for loose or omitted wires if the tubes do not light.

XIX. WIRING THE GRID CIRCUIT.

In wiring the grid circuit make the following connections. See figure 48, numbers 8 to 17 inclusive.

8. Join the grid post of tube 1 to one side of the grid condenser. Make this wire as short as possible. The one shown in figure 48 is too long. Then run a wire from the other side of the grid condenser to the fixed plates of the tuning condenser. This is the condenser at the left, as seen from the rear.

9. Connect wire number 8 to the inside terminal of coil S.

10. Join the movable plates of the tuning condenser to plus A on the upper rheostat.

11. Fasten the outside terminal of coil S to wire No. 10.

12. Attach the grid post of tube 2 to the right end of the neutrodon as seen from rear, and from that point continue the wire to the fixed plates of the volume-control condenser; join to the lower terminal. This is the condenser seen at the right when viewed from the rear.

13. Connect the outside terminal of coil A-S near aerial, to wire 12. Connect inside end to wire 15.

14. Join the other end of the neutrodon to the inside wire of the N-P coil.

15. Attach the movable plates of the volume-control condenser to the minus C battery.

16. Attach the plus C battery to the G terminal on the transformer. The red wire is the plus wire.

17. Connect the terminal minus F of the transformer to the minus A binding post.

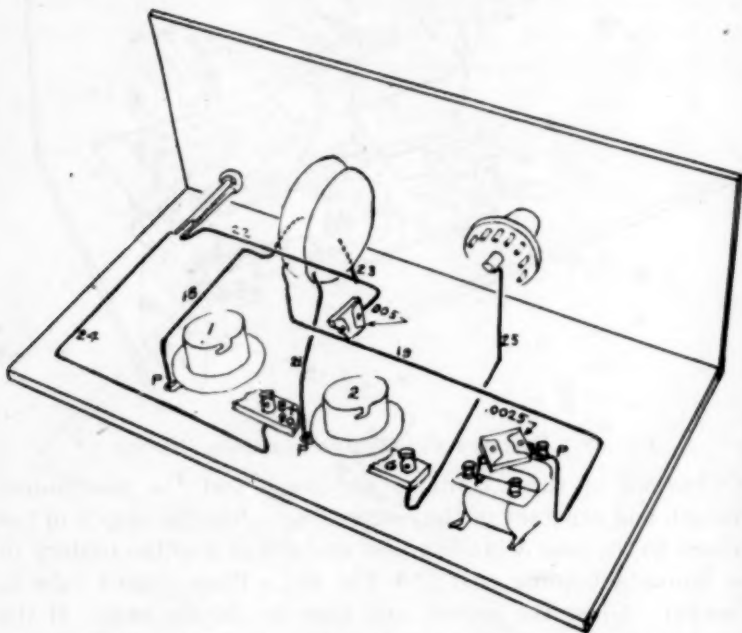


FIG. 49. DIAGRAM FOR WIRING THE PLATE CIRCUIT.

XX. WIRING THE PLATE CIRCUIT.

Make the following connections as shown in figures 49 and 50.

18. Connect the plate of tube 1 to the inner end of the tickler coil.

19. Join the outer wire of the tickler coil to the P terminal of the transformer. Place this wire under the neutrodon; cover it with spaghetti.

20. Attach the B-plus terminal of the transformer to the plus-B 22½ volt binding post. (Voltage here will depend upon the tube used.)

21. Connect the plate of tube 2 to the outside of coil N-P.

22. Join the other side of the .005 mfd. condenser (wire 6) to the lower terminal of the jack.

23. Connect the wire from the soldered terminal (middle) on the N-P coil to the wire leading to the jack (wire 22.).

24. Join the upper terminal of the jack to the plus-B 90-volts binding post.

25. Attach the ground binding post to the center of the aerial switch. Beginning at the switch the wire should go straight down to the base-board, follow the base-board closely, and come up under the binding post. Use spaghetti on this wire.

26. Join the aerial binding post to the inside of the A coil; the first tap to the left switch point, as seen from the front; the second tap to the second switch point, as seen from the front; and join the remaining taps to the switch points in order.

27. Connect the .0025 mfd. condenser across the transformer, one end going to P and the other end to minus F. This finishes the wiring of the set.

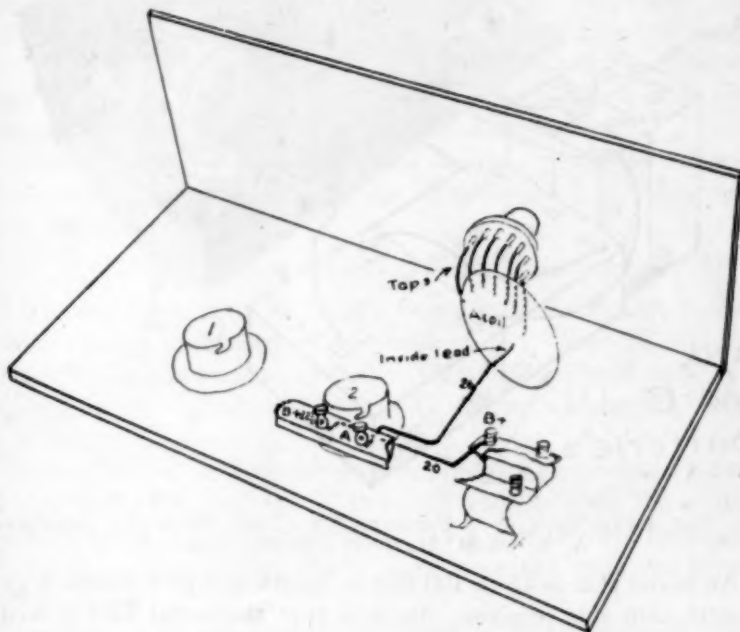


FIG. 50. CONNECTIONS FOR THE AERIAL COIL.

XXI. CHECKING THE WIRING AND TESTING.

The authors have used two methods for checking wiring. Figures 47, 48, 49 and 50 may be used and a red line drawn on each wire on the diagram after it has been firmly mounted in the set. When the original diagram has been changed to red lines the wiring is complete.

We call the other scheme the "proof-reader's method." One person inspects the set, wire by wire, while another reads the wiring directions. During this work one should tighten all screws and give all soldered connections a tap with a screw driver to test for faulty joints.

Figure 51 shows how to connect the A, B, and C batteries in making the final tests of the receiver. Watch for loose connections at the binding posts.

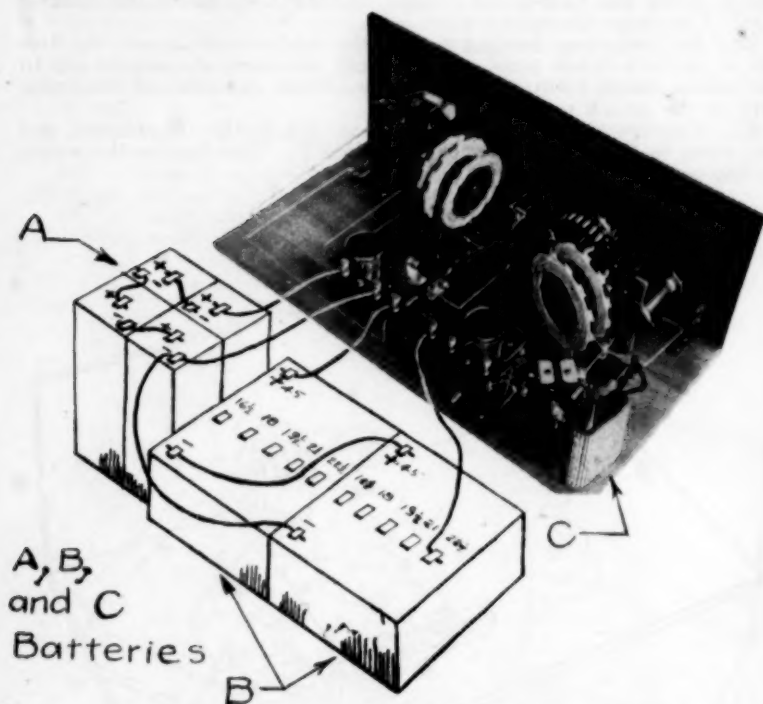


FIG. 51. REAR VIEW OF A FINISHED TWO-TUBE RECEIVER SHOWING A, B, AND C BATTERY CONNECTIONS.

An aerial that is 75 to 100 feet in length will give satisfactory results with this receiver. Be sure that the aerial wire is well insulated at each end and also where it enters the house. For experimental purposes, an aerial 8 to 10 feet in length has often given surprising results. Use a No. 14 wire for a ground wire and keep it as short as possible. A water pipe makes a good connection but a pipe or rod can be driven into moist earth (both winter and summer) as a substitute. Do not use a gas pipe.

In testing a receiver beginners, and sometimes more exper-

ience radio builders, sometimes fail to make all necessary connections. All the batteries must be connected; the aerial and ground wires must be attached. Then the telephone plug must be pushed into the jack; the switch must be turned on, and the rheostats turned up slowly. First try the aerial switch on the right hand tap or one of those nearest to it. Place the tickler in an almost vertical position and slowly rotate the right hand condenser dial. This is the tuning dial and locates the stations. Turn the left dial, which controls volume, so that the condenser plates are in about the same position as are those of the tuning condenser.

When a station has been located, record that dial reading. Then try the aerial switch on different taps until one has been located which gives the maximum volume when the dial readings on the tuning condenser and volume-control condenser are about the same. This is probably the best setting for the aerial switch. When the tickler is in a vertical position it produces squeals or whistles if it is working properly. If this does not produce whistling reverse the connections on the tickler. When a station is located by means of the tickler squeals, the volume and quality may be cleared by careful adjustment of the tickler and condensers.

XXII. NOTES FOR EXPERIENCED BUILDERS.

Winding forms may be made of cardboard or of fibre board which can be purchased at hardware stores. Note that there should be an odd number of spokes. The size given in figure 32 is satisfactory. Card or fibre may be cut with metal shears or a knife.

Better tuning adjustment can be obtained by mounting the A and A-S coils, and the N-P and S coils so that the space between them can be varied easily. This may be done by fixing the A-S coil to a sliding shaft, to be operated from the front of the panel.

Instead of the neutrodon suggested, a small variable condenser such as the Hammarlund may be used. This may be mounted on the panel above the large condensers.

(To be continued.)

A students' residence, or hostel, was recently dedicated with impressive ceremonies in Montevideo, Uruguay. The hostel is sponsored by a group of intellectuals to furnish home influences for students and to offer a center for the intellectual life of the community.

INDIVIDUAL INSTRUCTION IN A COURSE IN
DEMONSTRATIVE GEOMETRY.BY MARY A. POTTER,¹*High School, Racine, Wis.*

The first year I taught geometry, I had a rude shock that disturbed my self complacency. Viola, a good conscientious child but a nature designed dishwasher, came to me one day and said, "Miss Potter, I am getting along so well with my geometry!" I had noticed that if she got the proper start the theorem sang itself through quite merrily so I inquired, "How do you manage it, Viola?"

"Well," she said, "every night when I go to bed, first I say my prayers and then I say my geometry."

At this I realized that my proud boast of teaching Viola to reason had degenerated into teaching her how to memorize Mr. Wentworth's reasoning.

Other members of our department had experiences similar to mine. For some years we tried one plan and then another with indifferent results until four years ago two of the teachers proposed that we attempt to teach geometry by an individual method of instruction without using a formal text book. The consent of an open minded principal and superintendent making this experiment possible, we set to work at once writing what our pupils call a home-made text book which has since been twice revised and perhaps improved.

In form it is a loose leaf notebook of mimeographed sheets. In content it consists of an introduction with the customary statements of definitions, axioms, postulates, constructions and exercises. This is followed by the usual five books of geometry with those theorems and constructions recommended by the College Entrance Board and The National Committee—as our good friends the bookmen always remark. It differs from the traditional text book in that each theorem is presented as an original exercise. Our textbook contains only the statement of the theorems beneath which blank space is left for the figure, the "given," "to prove." The proof also is filled in by the student on a sheet of theme paper facing this mimeographed sheet. You will find distributed through the room copies of a completed theorem showing the typed statement and the parts filled in by the pupils. There are also several notebooks of this year complete up to last Friday that you may wish to examine.

¹Read before the mathematics section of the C. A. of S. & M. T. Nov. 1925, meeting, the University of Chicago.

A separate notebook is provided for each semester. At the end of the semester these notebooks are handed in to the teacher before a grade is given, and they are not returned. We like to assist the succeeding classes in keeping honest. At the beginning of the second semester sheets containing statements of theorems proved in semester I are provided for reference.

We attempt to introduce our pupils to geometry in quite the customary way by discussion and development of definitions, postulates, and axioms, enriched by constructions and exercises. We then present to them a mimeographed copy of the statement of those definitions, postulates, and axioms which we have laboriously worked out together.

The introduction safely made, we proceed cautiously to develop our first theorem on congruence of triangles. When we've done our best with this development the pupils are presented with a copy of that theorem written out in full and also a second mimeographed sheet containing the bare statement of the second theorem on congruence of triangles. With the lone suggestion that this may be proved by superposition, there are always at least four explorers in a class who are able to work out the complete proof with no further help. The first year we taught by this method, that first original proof gave us a decided thrill.

The class now passes through a transition period of socialized recitation. After a theorem has been successfully worked with as little help from the teacher as possible, a pupil demonstrates that theorem at the board before the class, while other pupils jot down comments on his recitation. At the conclusion of his demonstration pupils who wish to do so, challenge parts or all of this proof in the usual manner of a socialized recitation, framing their comments whenever possible in the form of questions. We have found this a most important stage in developing ability for analytical thinking and for that reason give them definite and rather elaborate training in how to ask a question. Ability to ask questions develops in about this order.

The pupil reaches the first stage when he knows a certain statement is correct. He arrives at the second stage when he not only knows that a certain statement is correct but that a second statement perhaps similar to the first is wrong. He now advances to the third stage when he not only is able to declare that one statement is wrong, but he is able to compare it with the correct statement and defend his position. In the fourth stage which

is that to which we try to lead our pupils, he not only knows that the true statement is correct, the false one wrong and why it is wrong, but he is able to ask thought provoking questions which recognize the difficulty presented and direct the student toward the correct conclusion without leading him to it.

For example, Ruth who is reciting says, "The whole is equal to the sum of all its parts." Harry who is at the first stage of development knows the statement is correct, and can say, "That's right."

If however, Ruth had said, "The whole is greater than the sum of all its parts," poor Harry would be lost; it sings all right.

But John, in the second stage, knows the statement is wrong and also knows the correct statement, hence he comments, "Ruth's axiom is wrong. She should have said, 'The whole is equal to the sum of all its parts.'" We are now free to choose between the truthfulness of John and Ruth.

Roy, however, has advanced farther—he not only knows why the statement is wrong but can offer arguments to prove his point, so he says, "The whole cannot be *greater* than the sum of all its parts. If that were true, we would never be willing to change a dollar bill for a half and two quarters." Perhaps he would then draw a circle on the board and divide it into parts to show that a whole circle is made up of the sum of all its parts.

But Anne at the ultimate stage, handles the situation quite differently. When Ruth has said, "The whole is *greater* than the sum of all its parts," she would offer no explanation, but begin a battery of questions such as "How does a dollar bill compare in value with a half dollar and two quarters?"

Ruth replies, "The values are equal."

Anne continues, "If we consider a dollar a whole thing, what would half and quarters be called?"

"Parts."

Then, "Remembering the dollar and its parts, how do anything and its parts compare?"

Ruth has arrived. "Oh, I see!" and quotes the correct axiom.

Often Ruth says, "Oh, I see!" sooner than this.

Of course this method of questioning is as old as Socrates, but its great age makes it no less important.

After this preliminary training of about eight weeks, we are ready for the final form of our work.

Later procedure is as follows: Students are given sheets containing the statement of all the theorems and corollaries

about a central topic and each student is held responsible for the proof of each of these. They are all attacked as original exercises. A pupil progresses at the rate of speed dictated by his own ability and ambition. He first writes up the proof of a theorem in his notebook and then asks to recite it. These numerous recitations are made possible only by the use of student teachers. After a student recites a theorem perfectly he is appointed a student teacher on that theorem and has other pupils assigned him for recitation. He is given instructions to report errors in proof, not to let the other pupil put anything over on him, and not to leave a theorem until he is sure his pupil understands it perfectly. Meanwhile, the teacher who is paid to teach acts as a general manager, qualifies different student teachers, assigns pupils to their student teachers so that several groups are working at one time, listens in occasionally to see that the student teacher is functioning properly, helps those who are in too great difficulty, and acts as arbitrator of disputes when different methods of proof are offered.

At first we neglected general class recitations, but we have found much was lost if we omitted this interchange of thought. We now spend about one-third of our time on general class recitation, drill, and 2 to 5 minute tests, and the remaining two-thirds on study and individual recitation.

The Racine High School is operated on a weighted credit system in which a student who passes in all his subjects may earn in one year from 32 to 52 hours of credit toward graduation, depending on the quality of his work. Hence it is necessary to make very definite standards of attainment for the different grades the students desire to earn. As I said before, the work is assigned by units, each unit is a topic or a phase of a topic and consists of the theorems, corollaries, exercises and often constructions on that topic. This unit of work is to be completed within a specified time—a two week's period is very satisfactory. We then advertise on the blackboard the number of theorems, corollaries, and constructions necessary to earn the various grades. We usually plan that a student who gets the highest grade must do at least twice as much work as the student getting the lowest passing grade. Exercises are divided into two groups, those for drill and those for credit. Drill exercises are worked at any fitting time during the unit of work and are thoroughly discussed in class. Exercises for credit are solved independently during a specified length of time in a class period. Difference

in ability and speed are shown with startling exaggeration here—some pupils who do passing work can solve successfully only three exercises while others do fifteen.

You say the book keeping for all this is rather complicated? Maybe, but like many other things it is a case of getting it down to a system.* Each of us has a slightly different method which doesn't seem to bother us unduly. Mine is as follows: I prepare a card for each unit of work like the one I have distributed. It contains at the left the names of the pupils in a class and at the top the numbers of the theorems, corollaries, and constructions in that unit. At the beginning of the class or at any time during the period, pupils come to my desk and write on a sheet of theme paper their names and the number of the theorem they wish to recite. As soon as possible I either hear them myself or assign them to a student teacher, writing the name of the student teacher after the name of the pupil who is to recite. The student teacher then records after his name the success of the recitation. Completed, each line reads something like this: (Dagmar Jensen Theorem 8 Jane Small O. K.) which means Dagmar Jensen recited theorem 8 to Jane Small successfully. Sometime during the class period I transfer this temporary record to the more permanent record of the card, putting a T for the pupil who becomes a student teacher on that theorem and a check for any other satisfactory demonstration. The card you have in your hand shows the actual record of my third period class last Thursday. As you observe, this class has an unusual range of ability. This card is always on display on the bulletin board. We believe again that it pays to advertise.

This individual method of teaching geometry is now being used in Racine for the fourth year in from six to eight classes each semester with a great variety of students. Those in classes this year vary in age from our infant of 10 to a young man of 22. Although geometry is an elective subject we have the mine run of students in our classes instead of the screened product. According to a survey of the school made last semester, their I. Q.'s vary from 85 to 133, but only 12% can rate 120 or better, more than half are below 110. Since the usual I. Q. for a senior high school student is about 112, I believe, our students are not unusually bright. Our pupils are chiefly foreign born or the children of foreign born parents from southern as well as northern Europe. Few of their parents have studied geometry, they haven't seen geometry books at home, and often late in their

course come to us with the discovery, "There's a geometry book in the public library that has the proof of the theorems written out complete." This is always delivered with a superior air; they seem to wonder that anyone should need so much help.

This method of instruction is not restricted to one teacher, but is used by four teachers who work together very closely, each keeping a careful notebook and each presenting criticisms and inspirations at a weekly luncheon meeting.

Of course this is a great deal of work for the long suffering teacher. Then why bother? We think it is worth while for many reasons. Our pupils like this method of instruction. Every year some of my former pupils ask me if they may hear the present class recite theorems after school or in their free periods. This method puts the pupil on his own responsibility and develops initiative. We rarely ask a pupil to recite a theorem, he asks us if he may. Formerly the game was to see if he could slip out of a recitation, it now is to see whether he can get a chance to recite. This attitude has lead to a happily low percent of failures—less than 5 percent.

Our geometry course has been enriched by new proofs for theorems that pupils have evolved. Not being restricted by a book to guide them, they have concocted wonderful proofs sometimes painfully long, but occasionally concise. Most of these proofs we have found in some text but a few are new to us and we can see nothing wrong with them.

It has been a rather humiliating experience to us who have taught geometry from a book for many years previous to find out how little geometry we really knew. When we have no sustaining prop of a text for authority we have had to search diligently through many texts, have argued fervently with each other and with our pupils, and have learned more geometry than we knew existed—enough that we are now very modest about our small store of knowledge.

Constant repetition makes the course thorough; the pupils cannot readily forget facts they have heard so frequently repeated.

Because theorems are presented somewhat in the form of an outline we find pupils organizing facts more intelligently about a central topic.

Moreover, we teachers like this method of instruction. At the end of every year we have frankly discussed returning to our old way of teaching, and every year we have unanimously

decided to continue because we feel so much better satisfied with our pupils' attitude and grasp of the subject. Our teacher judgment was confirmed by the record made by our pupils in the Schorling-Sanford Geometry Tests given last year in which our median was more than 25 percent above the standard. Although the price in labor is high, we are sold to an individualized method of instruction in geometry because of the increased dividends.

THE PSYCHOLOGY OF HIGH SCHOOL SCIENCES AND THE MAKING OF SCIENCE TEACHERS.

BY HERBERT BROWNELL,

Teachers College, University of Nebraska, Lincoln, Neb.

The attention of the writer recently has been called to some comments upon the teaching of science quite worthy the consideration of science teachers by reason of their source as well as their inherent worth. The excerpts more or less disjointed which follow indicate the tenor of several pages of comment in the Report¹ from which they are taken:

"For two generations a very considerable part, perhaps a major part, of the effort of educational systems and institutions has been expended upon the development of teaching and research in the natural and experimental sciences, and in making adequate provision for this work in men, in laboratories and in apparatus. * * * * Meanwhile the domain of science has itself expanded by leaps and bounds. * * * * Applications of scientific knowledge to practical life and to industry are multiplied many fold, and the daily life of millions of human beings is revolutionized and made vastly more comfortable, more safe and more healthy in consequence.

"The essential fact in all science study is the use and the comprehension of the scientific method. * * * * Every conclusion as it is reached is held subject to the results of verification, modification or overthrow by later inquiry or by the discovery of new methods and processes of research. * * * * One would suppose that after half a century of this experience and this discipline the popular mind would bear some traces of the influence of scientific method, and that it would be guided by that method, at least in part, in reaching results and in formulating policies in social and political life. If there be any evidence of such an effort, it is certainly not easy to find. Passion, prejudice, partisanship, unreason still sway men, whether as individuals or in the mass, precisely as if scientific method had never been

¹Nicholas Murray Butler: Annual Report (1925) to the Trustees of Columbia University. Pages 24-28.

heard of. * * * * Something must be lacking if intelligent men and women, long brought into contact with scientific method and scientific processes, pay no attention whatever to these, and show no effect of their influence when making their private or public judgments.

"One begins to suspect that the teachers of science themselves may have failed in making effective their science and their scientific method in this sphere of their larger usefulness. There can be no question that the decline in interest and authority of the ancient classics as educational instruments was hastened by, and indeed was in no small part due to, the manner of teaching those subjects which became substantially universal some sixty years ago. It is a sorry but safe reflection that had the classics been properly taught * * * in school and in college, they would not now be in so serious a situation. Can it be possible that something of the same sort is about to happen in the case of the natural and experimental sciences?

"Why must the science teachers of today * * * neglect the opportunity which is daily offered to make science and scientific method a real and commanding factor in the lives of tens of thousands of human beings by explaining to them what science is all about? Surely the example of the ancient classics ought to suffice. They were killed largely by those who taught them. * * * It would be poor business indeed if, while the ancient classics are being resurrected, the natural and experimental sciences should be led by their teachers into the valley of the shadow of academic death."

In thus seeing ourselves and our work "as others see us," let attention be turned anew to the statistical showing for secondary school science made more or less familiar to us all in one phase or another through oft quotation in recent years. (Bulletin 7:1924, Bureau of Education. Page 46.)

Percentage of Students in High Schools Taking Science Subjects.

	1890	1895	1900	1905	1910	1915	1922
Astronomy.....		4.79	2.78	1.22	.53	.28	.07
Physics.....	22.21	22.77	19.04	15.66	14.61	14.23	8.93
Chemistry.....	10.10	9.15	7.72	6.76	6.89	7.38	7.40
Physical Geography.....		23.89	23.37	21.52	19.34	14.58	4.28
Zoology.....					8.02	3.21	1.53
Botany.....					16.83	9.14	3.82
Biology.....						6.90	8.78
Geology.....		5.00	3.61	2.34	1.16	.48	.16
Physiology.....		29.95	27.42	21.96	15.32	9.48	5.08
Hygiene-Sanitation.....							6.06
General Science.....							18.27

COMMENTS.

The decadence of single science subjects might very properly be considered off-set to some extent at least, by an increasing range of subjects. Of late years chemistry has been more than holding its own. Some of the latest additions to the science list make a fine showing, although at the same time one is led to take under consideration the extent to which instruction in them *is upon a laboratory basis*, and to what extent a "scientific method of thought" and "attitude of mind" is likely to be developed and fixed.

From time to time through many years there have appeared articles and published addresses upon the teaching of science in which those interested in the promotion of science instruction in the public schools because of its educational values have voiced expressions of concern over an apparent failure to accomplish all desired. More or less urgently attention has been repeatedly called to conditions such as are set forth above, and to a need that these conditions be made better. It has been wearisome to make explanations and excuses for the lack of these evidences of the worth of science in public school instruction deplored by Dr. Butler. The stock excuses offered for schools in general have been the lack of suitably trained teachers, and a system of teacher-certification whereby anyone who might secure a position as a high school teacher thereby became a possible teacher of science subjects.² Then there were the further handicaps in science teaching of a larger cost-per-pupil for instruction in the science subjects, the distribution of "teaching load," and the difficulties naturally centering in and about laboratory management and equipment.

One turns with somewhat of a feeling of relief to what promises betterment at least in the training of science teachers for their work. And this rejoicing is the greater since the promise of aid comes from without the domain of the science work as such, and is a contribution from the field of education. A growing emphasis is noted in educational psychology to distinguish between the psychology of the teaching of science subjects, and that dominating the teaching of other subjects whether in high school or college. Teaching is teaching, of course, whatever the informational material employed; and teaching "folks" is to be distinguished from teaching subjects. Nevertheless, the con-

²Science Teaching and The Science Teacher; Brownell-Wade (1926). Century Company, Chapter XVII especially.)

tention of many science teachers holds that the manner of instruction characterizing the best in science teaching has long been sorely in need of such endorsement and confirmation as now is given by some workers in educational psychology.

The importance of educational psychology in the field of education, and particularly in teacher-training, thus arouses anew the hope of attaining in time those evidences of the worth of science in the public schools which Dr. Butler declares lacking. It is true that the importance of a psychological basis for science instruction, and different from that which supposedly shapes the teaching process in other groupings of school subjects, has been set forth admirably in various books upon the teaching of science.³ Yet any growing emphasis in educational psychology upon the existence of a psychology *sui generis* for the teaching of science subjects becomes promise of better science instruction.

It should be kept clearly in mind, however, that special instruction upon the psychology of the teaching of science subjects presupposes a working knowledge of the sciences to be taught, and in general of the various related sciences. In the teaching of any science its subject-matter must ever be the means employed to provoke thought-effort, and to provide thought material. Methods of instruction for science subjects in the work of teacher-training are best developed, too, from selected parts of the subject-matter to be taught. "Practice teaching" and "methods" should inter-act, and be inter-related. The psychological principles which under-lie the teaching of science subjects in general may thus largely determine if not completely dominate methods of teaching these subjects, and govern as well the teaching procedure followed. This is as true for beginners in teaching who are untrained for public school service as in the "practice teaching" of Normal Schools and Teachers Colleges in the degree to which it is wisely ordered and effective.

Discussions of the psychology of the teaching of science subjects as differentiated from the teaching of other subjects belong then in the "science" department rather than in the department of psychology. Applications of psychological principles may then be made direct in the methods courses in science, and in the training courses for the acquisition of teaching skill. There is unification then rather than dismemberment in teacher-training

³The Teaching of Chemistry and Physics: Smith and Hall (1902). Longmans, Green, and Company.

⁴Science Teaching: Twiss (1917). The Macmillan Company.

for science instruction. Either those who instruct in science subjects must be acquainted with the teachings of educational psychology, or teachers of this latter subject must themselves become masters in the field of science. College instructors in science have perhaps been slow in recognizing any need for courses taken in education preparatory to their teaching, and thereby may be deemed the more culpable for such conditions as are set forth by Dr. Butler. And in this connection it may not be out of place to call attention to the fact that crowded laboratories and lecture halls in use for science teaching in colleges and universities in no measure indicates a dominant purpose on the part of college students for scientific knowledge, or for that "scientific attitude of mind" supposedly product of science instruction. Science subjects as "group requirements" may continue to figure large among college courses, and hold their place in high school curricula, while at the same time there are lacking evidences of the "influence of scientific method" to an appreciable extent. Any charge of failure in having a scientifically-minded citizenship is not met at all adequately by numbering the students "taking science" in college.

Trusting as the writer does that a demand for science instruction will continue, insuring as this will a continuance of science subjects as courses in the public schools and in colleges, despite the discouraging array of figures above and the rather doleful predictions made; and having made due allowance for such improved conditions as may develop through a better psychological basis in science instruction, there must ever remain as the indispensable factor in science teaching the fitness of the instructor for this teaching work. And this fitness involves professional training in addition to mastery of the subject-matter of the sciences which are taught.

"Great students" (and great teachers, too) "have been formed one by one."⁴ Quantity production does well enough in the industrial world. It serves admirably when the product is pins, tooth-picks, or Ford cars. But in the making of an intelligent and scientifically-minded citizenship, mass-instruction and radio courses are unsuited for the study of scientific "problems," at least in beginner courses. It is passing strange the extent to which in high school and college courses "exposure" to science teachings and scientific training can be withstood by students

⁴Professor Andrew F. West, Ed. Rev.: September, 1908.

without becoming infected with zeal for its teachings, its methods, and its attitude of mind. Dr. John C. Hessler, in an address some years ago,⁸ outlined what seems to the writer of far greater worth in advancing the interests of science in public education than any amount of academic discussion of whether or not science teaching will survive. His suggestions are constructive. They are not confined to teacher-training alone, but have to do with science teaching in its subject-matter and method. Concerning his concise but illuminating argument for generalized rather than specialized courses, and his argument for "professors of science" (not any single science), we cannot do better than quote briefly:

"Only here and there can one find high school science being taught in a really efficient and inspiring manner. * * * * Let us suppose that the teacher was trained to teach chemistry. He will be found teaching physiography, physiology, botany, perhaps even physics, in all of which he may have had practically no preparation. He is fortunate if he is not called upon to teach science after preparing himself especially in english or history. * * * * If you ask the teacher * * * * he responds that he is expected to take the work assigned him. Since he had studied something of one science he is expected to know science in general. * * * * The pupil, too, learns his science as too often he learns algebra and Caesar and composition—things to receive grades upon, to "pass," and never to be bothered with again. Let it be understood at this point that it is of no use * * * * to blame the young high school teacher for the situation in which he finds himself. He is but adapting himself to conditions as best he can."

"What can the college contribute to science in the high school? It can, in the first place, recognize the problem. * * * * The self-evident remedy, if experience and reason teach us anything, is that the college and the under-graduate departments of the university must adapt a part of their instruction in science to the training of their graduates *to be teachers of science* rather than *teachers of a science*."

"How can this be done? One way that suggests itself is that the college can expect those of its students who have any idea of teaching to take elementary courses in several sciences rather than to specialize in one. * * * * There is, however, a still better way of solving the problem. The college can select from

⁸SCHOOL SCIENCE AND MATHEMATICS, XVII:511 (1917).

its faculty a man who can appreciate the specialist's point of view and who can yet see the science field as a whole, a man who can make for this purpose a re-synthesis of science out of the fragments into which for purposes of intensive study it has been broken. This man can present to students of the third or fourth year a course in "The Teaching of Science." As a prerequisite, students should be required to take courses in both the physical and biological branches of science. In this way the elements of some sciences not ordinarily taken by college students, such as astronomy, may be added to the graduate's equipment.

"To the student who majors in biology this teaching course will give aid in the physical sciences, while to the student of physical science it will give the necessary minimum of biology. To both classes the course will give the equipment and point of view needed for the presentation of introductory science, or general science, in the junior high school or the first year of the ordinary high school—a need not met by any college science courses of the present time."

"As the inexperienced high school teacher will inevitably teach in the high school the thing last studied in college, let that last thing studied be a unifying course rather than a specialized one. * * * Without abandoning the special skill he has gained, he will yet come to feel the essential unity of the truths of science before he goes out to present them to the next generation. This will make of the graduate not only a better teacher but a better man or woman."

THE ELECTRIC DOUBLER.

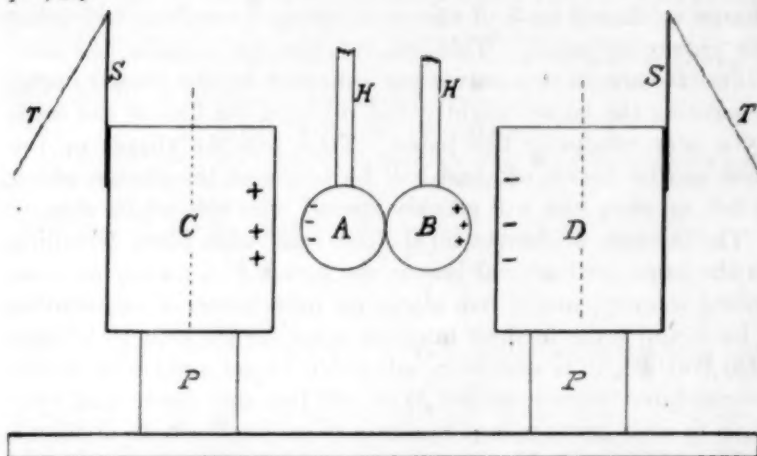
By W. S. FRANKLIN,

Massachusetts Institute of Technology, Cambridge, Mass.

The demonstration of the electric doubler (Lord Kelvin) is, in my opinion, the most interesting and the most instructive of all the class-room experiments in electrostatics. Two metal balls *A* and *B* have quartz handles *H H*. Two open metal cans *C D* stand on paraffine pillars *P P* and fine cotton threads *T T* are fastened to the metal strips *S S* which are soldered to *C* and *D*.

Ordinarily we think of the cans *C* and *D* as having no electric charge, after they have been touched by the hands for example, but as a matter of fact they always do have extremely minute charges; for the sake of argument, therefore, let us assume that *C* has an extremely minute positive charge $+Q$ and that

D has an extremely minute negative charge $-Q$. When the two balls are placed in contact with each other as shown in the figure a charge $+q$ is induced on B and a charge $-q$ is induced on A , and for a given piece of apparatus q is a definite fraction of Q . Let us suppose this fraction to be $\frac{1}{2}$; that is $q = \frac{1}{2}Q$.



Now holding A and B by the quartz handles, separate A and B slightly, put A inside of can D (in contact with D), and put B inside of can C (in contact with C). Then, as was first shown by Faraday in his famous "ice pail" experiment, A gives *all* of its charge to D and B gives *all* its charge to C no matter how large or small the original charges on C and D may be. Thus the charges on C and B have been increased to $\pm 1\frac{1}{2}Q$.

Repeat the whole operation and the charges on C and D will be again multiplied by $1\frac{1}{2}$ and become $\pm 2\frac{1}{4}Q$, or repeating the whole operation n times, the charges on C and D will be $\pm (1.5)^n Q$ if leakage is negligible. Thus if $n=100$ we find that $(1.5)^{100} = 410,000,000,000,000,000$; and, even if the original charge Q is the charge of a single electron or positive ion, we will have gotten a very perceptible amount of charge on the two cans as will be shown by the divergence of the two threads. Indeed 60 or 70 repetitions of the multiplying operation will give a sufficient voltage between the cans to produce an audible spark when the cans are brought near together or when a "discharger" is bridged across from can to can. In fact, it is easy thus to get a spark $\frac{1}{2}$ cm. long which means about 15,000 volts between the cans.

After 60 or 70 repetitions of the multiplying operation the accumulated charge can be drawn off of *C* and *D*; but if this is done one would have to perform the multiplying operation 60 or 70 times, again, to build up the large charge. If the device is to be employed to develop electric charges for outside use, it is decidedly best to take off, say, about half of the accumulated charge so that 2 or 3 of the multiplying operations will bring the charge up again. This can be done by splitting the cans *C* and *D* each in two halves (as indicated by the dotted lines), separating the halves slightly and bridging the gap in the walls by a poor conductor like paper. Then half the charge on the cans can be drawn off, and half be left; and the charge which is left on each can will quickly spread over the whole can.

The increase of charges on the two cans takes place according to the same arithmetical law as the increase of money at compound interest, and if one places an investment of one cent in a bank and waits for four hundred years for the cent to become \$131,000,000, it is decidedly advisable to use only half of the accumulated money rather than all but one cent, and thus have to wait another four hundred years for the next dividend.

The electric doubler with split cans is in every essential detail identical in its action to the familiar Toepler-Holtz influence machine.

JOYOUS DEMONSTRATION AT PACIFIC COLEGE.

Recognition by the Oregon State Department of Education of Pacific College, Newberg, Oreg., as a "standard college" was made the occasion of an enthusiastic demonstration. The students paraded the streets with noise makers in great variety and gave every evidence of joy. A formal official celebration was held later.

In accordance with an act of the Oregon Legislature the Bureau of Education of the Department of the Interior was requested to classify the higher educational institutions of the State, and it was in pursuance of this act that Pacific University was recently rated as "standard."

CZECHS IN MARVELOUS GYMNASTIC MASS DRILLS.

"Sokol," Czechoslovakia's great organization for physical education, will hold its eighth Slet, or national sexennial meet, at Prague in June, 1926. The gymnastic mass drills which are the feature of these meets are marvels of alignment and exactness, writes Emanuel V. Lippert in *SCHOOL LIFE*, a periodical published by the Interior Department, Bureau of Education. In the coming displays about 29,121 men will appear in a combined drill in the great arena at Brevnov, and later about 16,793 women will participate simultaneously in their own drills. It is expected that thousands of foreign visitors will witness the exhibitions, and that practically the entire population of Prague and the vicinity will attend.

PROBLEM DEPARTMENT.

CONDUCTED BY C. N. MILLS,

Illinois State Normal University, Normal, Ill.

This department aims to provide problems of varying degrees of difficulty which will interest anyone engaged in the study of mathematics.

All readers are invited to propose problems and to solve problems here proposed. Drawings to illustrate the problems should be well done in India ink. Problems and solutions will be credited to their authors. Each solution or proposed problem, sent to the Editor, should have the author's name introducing the problem or solution as on the following pages.

The Editor of the department desires to serve its readers by making it interesting and helpful to them. Address suggestions and problems to C. N. Mills, Illinois State Normal University, Normal, Ill.

SOLUTION OF PROBLEMS.

Editor. Readers of the SCHOOL SCIENCE AND MATHEMATICS may be interested in a generalized solution of Problem 888.

Solved by Michael Goldberg, Philadelphia, Pa.

If a^n and a leave the same remainder when divided by s ,

$$\frac{a^n - a}{s} = \frac{a(a^{n-1} - 1)}{s}$$

is an integer.

By Fermat's theorem

$a^{p-1} \equiv 1 \pmod{p}$, or $a^{p-1} - 1 \equiv 0 \pmod{p}$, where p is a prime number which will not divide a .

If $s = p_1 \cdot p_2 \cdot p_3 \cdot \dots \cdot p_r$ = product of r different primes and $n-1 = m(p_1-1)(p_2-1)(p_3-1) \cdot \dots \cdot (p_r-1)$ = totient of s , then $a^{n-1} \equiv 1 \pmod{s}$. If $a^{n-1} - 1$ is divisible by each of the r different primes, it is divisible by their product. Therefore $a(a^{n-1} - 1)/s$ is integral, for the factors of s not contained in a are contained in $(a^{n-1} - 1)$. The relation does not hold true when a factor of s is repeated. Hence, s is the product of r different prime numbers $p_1, p_2, p_3, \dots, p_r$, while $(n-1)$ is a multiple of $(p_1-1)(p_2-1)(p_3-1) \cdot \dots \cdot (p_r-1)$.

911. Proposed by Victor A. Ivanhoff, Philadelphia, Pa.

Solve the given equation for integral values of x, y and z .

$$\sqrt[3]{x^3 + y^3 + z^3} = \frac{1}{2}(x + y + z).$$

Solved by the Proposer.

The easiest way to solve the equation is to use the formula $x^3 + y^3 + z^3 = (6n)^3$, or $3^3 + 4^3 + 5^3 = 6^3$, which should be kept in mind (like the formula for the "Egyptian Triangle"). Hence, the substitution gives the solution without difficulties, $6 = \frac{1}{2}(x + y + z)$, or $12 = x + y + z$, and $12 = 3 + 4 + 5$. Then the roots of the original equation are: (I). $x = 3, y = 4, z = 5$; (II). $x = 4, y = 5, z = 3$; (III). $x = 5, y = 3, z = 4$.

A useful interpretation of the formula can be made by considering the sum of the volumes of three cubes having sides of 3, 4 and 5 respectively, which equals the volume of one cube with a side 6.

912. Proposed by Nathan-Altshiller-Court, University of Oklahoma.

If the distances of the vertices of a triangle from two given points are proportional, the two points lie on a diameter of the circumscribed circle of the given triangle.

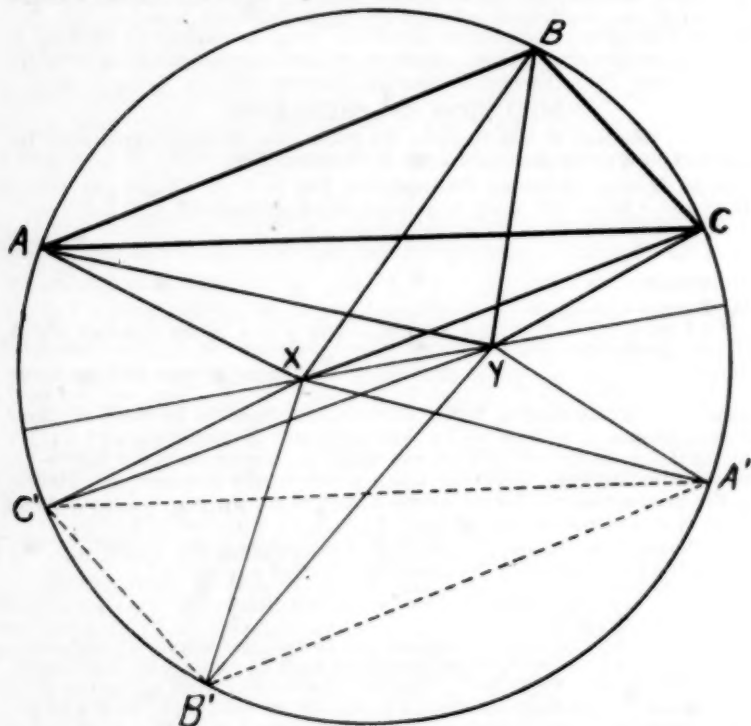
I. Solved by George Sergeant, Tampico, Mexico.

Let P and P' be the given points, ABC the given triangle. By conditions of the problem $PA : PB : PC = P'A : P'B : P'C$. P and P' are common to three circles, L, M, N , whose diameters DD', EE', FF' , are the segments determined on AB, BC, AC , respectively, by the interior and exterior bisector of each of the angles APB, BPC , and APC . The centers L, M, N , are on the perpendicular bisector of their common chord, PP' , which is their common radical axis. Hence, $AD' : AD = BD' : BD$.

LD is one half of DD' . By a property of the harmonic division, we have $LD^2 = LA \cdot LB$, which shows that LD is equal to the tangents

drawn from L to any circle passing through A and B , and also equal to the tangent drawn from L to the circumcircle O , of the given triangle. It follows that the circle L and O intersect orthogonally. In the same way, from $\overline{ME}^2 = MB \cdot MC$, and $\overline{NF}^2 = NA \cdot NC$, it can be shown that the circles M and N intersect the circle O orthogonally. Therefore the tangents from O to the circles L, M, N , are radii of the circle O . Hence the center of the circumcircle must be on the common radical axis of circles L, M, N , which is their common chord, $P'P$, produced.

II. Solved by Velma Knox, Redlands, Calif.



First, the radius BO is extended to the opposite point on the circumference of the circle, and point B' is located. Then radius AO is extended and point A' is located. In like manner point C' is located. Triangle $A'B'C'$ is drawn and from its vertices, lines are drawn to points X and Y . A line not known to be the diameter is drawn through points X and Y .

Triangle ABC equals triangle $A'B'C'$. (Proof). Point B' is directly opposite point B . (B' having been located by the extension of BO .) In like manner A' is opposite A and C' is opposite C . Triangle $A'B'C'$ is inscribed in the same circle, therefore the triangles are equal.

Since triangles ABC and $A'B'C'$ are equal and inscribed in the same circle, the lines drawn from their respective vertices, to the same points, would be respectively equal. Then $B'X$ equals BY and $B'Y$ equals BX . XY equals XY , therefore triangles BXY and $B'XY$ are equal. (Two triangles are equal when their respective sides are equal.) In like manner triangle $C'XY$ equals triangle CXY and $A'XY$ equals AXY .

Now, since these triangles are equal and one of their vertices lies on the circumference of the circle, their common base would have to be the diameter, for if it were not, one triangle would be smaller than the other.

Also solved by Michael Goldberg, Leonard Carlitz, Philadelphia, Pa.

ESSENTIALS of PLANE and SOLID GEOMETRY

By DAVID EUGENE SMITH

Limits the number of proved propositions to meet the syllabus given in Chapter VI of the report of the National Committee by selecting the great basal theorems and effectively organizing them into a logical system. The Smith and Wentworth-Smith geometries are now used in

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MOON VISIBLE DURING POLAR WINTERS.

The six months night which residents near the north pole enjoy during the winter, and which will soon come to an end, is not as dark as it might seem, for they have the moon above the horizon for two weeks at a time. To an observer at the pole, it would be seen to rise at the first quarter, would wax to full and wane to last quarter again before it set below the horizon. This is because of the fact that when the moon is full, it is on the side of the earth directly opposite the sun. This can be verified by anyone, for when the moon is full, it rises as the sun sets, and is on the meridian, directly south, at midnight. At first quarter the moon is directly south as the sun sets, while it sets at midnight; and at last quarter, Luna appears above the eastern horizon at midnight.

During the autumn and winter months, while the sun is south of the equator, it is not visible at the north pole, but it is not dark all of the time, for the sun must be about 18 degrees below the horizon before the sky is actually dark. When it is less than 18 degrees, twilight occurs. During the past winter, the sun was below the twilight limit from November 14 to January 29, making a total of only about two and a half months of actual night. With a bright moon during half of this time, the pole has a total of only a little over a month of actual darkness during the year. However, there is less heat in the winter, and so Arctic explorers find the summer the most comfortable for their work. Perhaps the day will come, however, when the transpolar air route to Europe and Asia will be popular, since the light will make possible flying at all times of the year.—*Science Service.*

913. An error was made in setting up this problem, hence no solutions were possible. *Editor.*

914. *Proposed by Leonard Carlitz, Philadelphia, Pa.*

Find the value of the continued product

$$\frac{2}{\sqrt{2}} \cdot \frac{2}{\sqrt{2} + \sqrt{2}} \cdot \frac{2}{\sqrt{2} + \sqrt{2} + \sqrt{2}} \cdots$$

Solved by Raymond Huck, Shawneetown, Ill.

Let P represent the given product.

$$P = \frac{\sqrt{2}}{1} \cdot \frac{\sqrt{2}}{2} \cdot \frac{\sqrt{2}}{3} \cdots$$

The product of n such ratios would be $P_n = 2^{\frac{n}{2}} / n!$. Adding and subtracting $2^{\frac{n}{2}}$ from the right member, we have

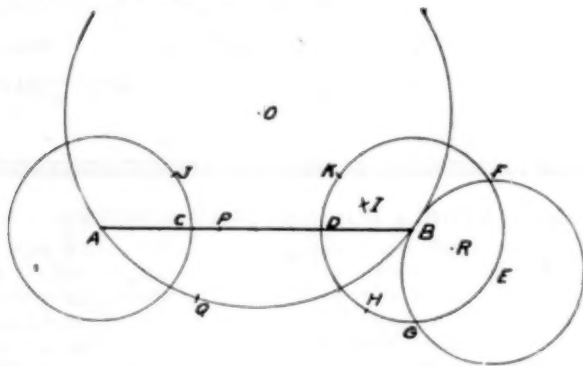
$$P_n = 2^{\frac{n}{2}} \left(\frac{1}{n!} + 1 \right) - 2^{\frac{n}{2}}$$

$$\text{If } n \rightarrow \infty, \frac{1}{n!} \rightarrow 0, \text{ and } P_n = 0.$$

Also solved by *T. E. N. Eaton, Redlands, Cal.*; *George H. Gatje, Islip, L. I., N. Y.* A solution involving a continued fraction interpretation was sent in by *Michael Goldberg, Philadelphia, Pa.*

915. *For High School Pupils. Proposed by the Editor.*

Give the proof of the construction of Solution II for Problem 897, which appears in the February issue.



897. *Proposed by F. A. Cadwell, St. Paul, Minn.*

Using the compasses alone, divide a given line segment into two parts, one part being equal to the side of regular decagon inscribed in a circle whose radius is equal to the other part.

Solved by the Proposer.

Let AB be the given line segment. With A and B as centers and equal radii shorter than AB (preferably and in this solution shorter than $AB/2$) draw circles intersecting AB at C and D . Take any point as E , on circle B , as a center and with a radius equal to EB draw a circle intersecting circle B at F and G .

By the method used in the solution of problem 658, November, 1920, find H on circle B which shall be a corner of a square of which B and E are also corners.

With F and G as centers and radii equal to HE draw arcs intersecting at I . With C and D as centers and radii equal to BI draw arcs intersecting circle A at J and circle B at K . By the method used in the first solution of problem 869, May, 1925, find O , the point of intersection of the lines

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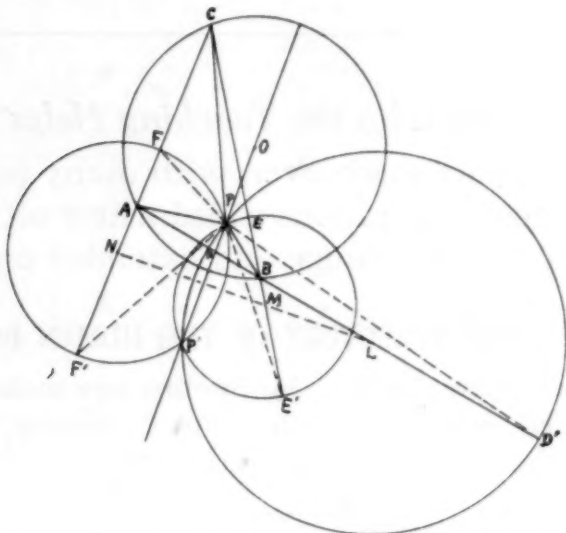
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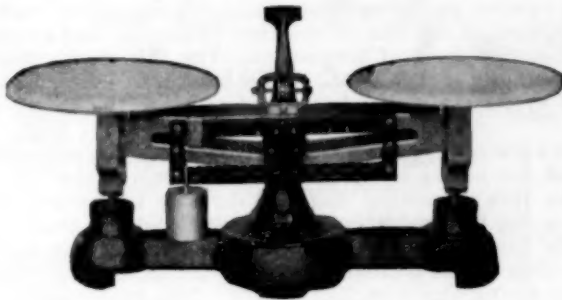
Proof. With O as a center and OA as a radius draw a circle. Since A and B are equal circles and CJ and DK equal arcs, angles AOB and OBA are equal. Hence, OA = OB. Therefore, a circle drawn with O as a center and OA as a radius will pass through A and B. Let R be the point of intersection of FG and BE, and let Q be the point where the radius of the circle O drawn through P meets circle O. Since B and E are equal circles FG and BE bisect each other at right angles. I is (by construction) equi-distant from F and G. Hence, I is collinear with B and R. Therefore, RIG and BRG are triangles right-angled at R. It is not difficult to prove that $(RI)^2 = (RH)^2 = 5(BR)^2$. Hence, RI = RH. Also, BI is equal to the side of a regular decagon inscribed in circle B. Since A and B are equal circles, and CJ and DK are (by construction) equal to BI, CJ and DK are the sides of regular polygons (decagons) inscribed in circles A and B. Triangles AOQ and PAQ are similar, and each is isosceles. Hence, AP is equal to the side of a regular decagon inscribed in a circle whose radius is equal to BP.



$$a^2 + b^2 + c^2 = ab + ac + bc.$$

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OYSTERS GROW BEST IN HARBORS.

"Back to nature" is the slogan of the experts who are trying to coax the oyster back to its old time productivity. Oysters live, thrive, increase, and multiply best in the brackish waters of our coastal estuaries and harbors, according to H. F. Prytherch of the U. S. Bureau of Fisheries. At the experimental shellfish laboratories at Milford Harbor, Conn., experiments have been made to determine if oysters cannot be induced to become as plentiful in their native haunts along the New England coast as they were in the days of Massasoit and Miles Standish.

The oyster spawn is microscopic in size and for two weeks exists in a free swimming larval state carried hither and thither by the waves and the tide. The great key note of oyster culture is to get the largest number possible of the baby oysters to "set" upon some stationary object at the end of the free swimming stage. Once set the oysters cannot move of themselves. The full grown marketable adults can readily be collected from whatever planted material, usually old oyster shells, has been used to catch the young ones or "spat."

At Milford Harbor for the past four years many experiments have been carried out in the study of the life history of the oyster, particularly the free swimming stage. Very few larvae are found in the water in the interval between spawning and the time for them to set. The investigations this summer show that the larva lives part of the time on the bottom during this period, pulling itself along by means of a muscular foot, like a clam. This interesting discovery has enabled investigators to understand much better the relationship of spawning beds and setting areas and the effect of tides and currents on distribution.

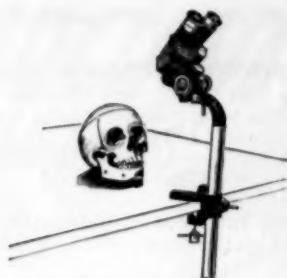
Rocks, shells, glazed tile, and objects of many sorts were tried out as collectors for the "spat." Birch brush, bearing dozens of tiny oysters planted in rows in the tidal flats, presented the aspect of what might be called an oyster garden. The outstanding results of the summer's work show that millions of seed oysters can be produced when natural conditions of breeding are reproduced. Protection of these inshore areas is essential if the oyster is to continue to be a delicacy of the American table.

Thousands of dollars have been spent by commercial enterprises sowing oyster shells to collect seed oysters, with steadily decreasing results. In years past when the oyster industry has been successful in obtaining yearly crops of oysters there were large natural beds located in the harbors, bays and river mouths where the conditions were favorable for the production of a vast quantity of spawn. Today these valuable areas have been destroyed by excessive pollution from factories and by overfishing so that only the deep water beds remain for the production of seed oysters.

When spring and summer weather conditions in deep beds resemble those normally existing in the harbors and estuaries, oyster culture is successful, but unfortunately this happens only occasionally. Connecticut recently passed a law enforcing the control and elimination of pollution in its harbors. The enactment and enforcement of such legislation in other oyster growing states would do more than any other one thing to increase the existing supply of oysters. This spring the Bureau of Fisheries intends to undertake an investigation of the coast of South Carolina to ascertain the possibilities for oyster propagation in the South. A similar survey of Texas is already under way.—*Science Service.*



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BOOKS RECEIVED.

Birds of Massachusetts and Other New England States, by Edward Howe Forbush. Illustrated with colored plates by Louis A. Fuertes. Pages xxxi+481. 20x25½ em. 1925. Cloth. Published by the state.

Junior High School, by William A. Smith of University of California, Southern Branch. Pages xiv+478. 14x19 em. Cloth. 1925. MacMillan Co., N. Y.

Origin of Nature and the Influence of Relativity, by George A. Birkhoff. Pages xix+185. 13½x19½ em. 1925. Cloth. MacMillan Co., N. Y.

Modern Method of Teaching Arithmetic, by Ralph Newcomb of State Teachers College, Ada., Okla. Pages 15+353. 13½x19 em. Cloth. 1925. \$2.00. Houghton Mifflin Co., Boston.

Second Course in Algebra by John C. Stone of State Normal School Montclair, N. J. and H. F. Hart of Senior High Schools, Montclair, N. J. Pages xiii-294. 13½x19 em. 1926. Cloth. Sanborn Co., Chicago, Ill.

Junior Mathematics Book III by Ernst R. Breslich of University High School, University of Chicago. Pages viii-254. 13x19 em. Cloth. 1926 MacMillan Co., Chicago, Ill.

College Algebra by William L. Hart, of University of Minnesota. Pages 8-360-36. 14x20½ em. Cloth. 1926. D. C. Heath and Co., Boston.

New Mathematics Book I, John C. Stone State Normal School, Montclair, N. J. Pages cii-314. 13½x19 em. Cloth. 1926. Benjamin Sanborn Co., Chicago, Ill.

The Practice of Teaching in the Secondary School by Henry C. Morrison, University of Chicago. Pages viii+661, 16x23 em. Cloth. 1926. \$4.00. The University of Chicago Press.

NEW ENGLAND ASSOCIATION OF CHEMISTRY TEACHERS.

This association will hold its hundredth meeting on May 1, at Boston College. As this is an unusual occasion, the committee on arrangements has prepared a program of uncommon interest.

On Friday evening preceding the meeting, a banquet for members of the association and friends will be held at a place centrally located in Boston. The banquet price has been fixed at two dollars. The chief speaker at the post-prandial exercises will be Dr. James F. Norris, president of the American Chemical Society, and other speakers of note will deliver brief remarks. Informal dress will be appropriate to the occasion.

The program for the following day, Saturday, May 1, is replete with interest. Address of welcome by the president of the college; Dr. C. E. Bolser of Dartmouth College will speak on "Some Contributions of Chemistry to Medicine"; Rev. J. A. Brosnan will speak on "Color Photography to Date" and will illustrate his remarks with slides, specimens, and a moving picture in the natural colors of a volcano in eruption; Dr. H. F. Davison of Brown University will speak on "New Lecture-Table Demonstrations" illustrating his remarks with the demonstration of new apparatus. Those who have heard any or all of the above speakers will be certain of the rich treat that is in store.

Members of the Association and their families and friends will be the guests of the college at luncheon, a courtesy highly appreciated.

For the afternoon the speaker will be Dr. Charles H. Herty of New York, president of the Organic Manufacturers Association. His address will deal with some applications of Organic Chemistry to Industry. Dr. Herty is a speaker of rare charm and interest and the Association is to be congratulated in securing so attractive a speaker.

Other features of interest will be announced later.

Members coming from a distance and desiring accommodations for over Friday night, and members residing in and near Boston who are willing to receive guests for over Friday night, should communicate with Mr. William W. Obear, High School, Somerville, Mass., who will look after the necessary arrangements. Those desiring tickets for the banquet should communicate with Mr. Shipley W. Rieker, 14 Brooks St., West Medford, Mass., who has the matter in charge.

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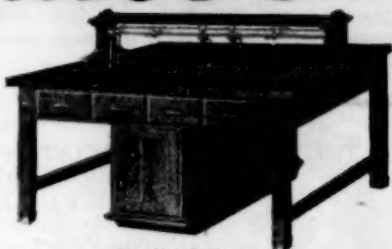
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It is desired that the largest possible attendance be recorded for this rare occasion. Make your plans now to come for both the banquet and the meeting of the following day. Officers will be elected and other business transacted at the business meeting on the morning of Saturday, May 1.

CHARLES H. STONE,
Chairman.

THE LANGLEY ASSOCIATION OF SCIENCE TEACHERS— SPRING MEETING.

PITTSBURGH, PA., APRIL 23 AND 24, 1926

The spring meeting of the Langley Association of Science Teachers will be held in Pittsburgh, Friday and Saturday, April 23 and 24, 1926. The dinner will occur Friday night at 6:30 in the Bureau of Mines banquet room. The past presidents will be both guests and hosts. Tickets for the dinner, \$1.00, should be reserved in advance by writing to the secretary.

The association has accepted the kind invitation of the Carnegie Institute of Technology to be their guests at the university annual Open House program. Under guidance of some member of each department the science sections will leave the Bureau of Mines at 8:00 p. m. for the building of their choice (Biology, Chemistry, Physics, Engineering, Geology, etc.) where special exhibits will be explained and continuous demonstrations given from 8:00 to 10:00 o'clock.

Saturday morning The Langley Association will convene at 9:00 in room 109, Schenley High School, to consider the general topic of "Science in Industry." Leaders in the industrial world will outline and illustrate their processes. At 11:00 a. m. the Langley Association of Science Teachers will adjourn until October and join in the general meeting of the Education Association of Western Pennsylvania, which is the Western Convention District organization of the Pennsylvania State Education Association.

PROGRAM.

Friday Evening, April 23, 1926, Bureau of Mines.

- 5:30 p. m. Reception at the Bureau of Mines Auditorium.
- 6:30 p. m. Dinner, Past Presidents as guests. Bureau of Mines banquet room. Reservations should be made in advance by writing the secretary. The after dinner speaker will be Dr. Fallows, of the Carnegie Institute of Technology.
- 7:45 p. m. Business meeting. Adjournment by Sections.
- 8:00 p. m. Special demonstrations at Carnegie Tech. The science sections of biology, chemistry, physics, general science, etc., will be escorted to the annual exhibitions held at the university.

Saturday Morning, April 24, 1926, Room 109, Schenley High School.

- 9:00 a. m. Motion pictures. Visual Education and the Teaching of General Science, by Jasper T. Shriner, Latimer Junior High School, Pittsburgh, Pa.
- 9:30 a. m. Address, by Chief Chemist H. V. Churchill of The American Aluminum Co. "Aluminum—A Pittsburgh Product."
- 10:00 a. m. Address, by Mr. A. D. Terrel of American Zinc and Chemical Company. "Zinc from the Ore."
- 10:30 a. m. Discussion.
- 10:45 a. m. Adjournment to auditorium for the general meeting of the Education Association of Western Pennsylvania.
- 11:00 a. m. Executive committee meeting, officers and past presidents. Officers of the Langley Association of Science Teachers—President, Clarence E. Baer, Head of Science Department, Senior High School, New Castle, Pa.; Vice President, E. R. Carson, South Hills High School, Pittsburgh, Pa.; Treasurer, David W. Rial, Westinghouse High School, Pittsburgh, Pa.; Secretary, Frank W. Murphy, David B. Oliver Junior High School, Pittsburgh, Pa.

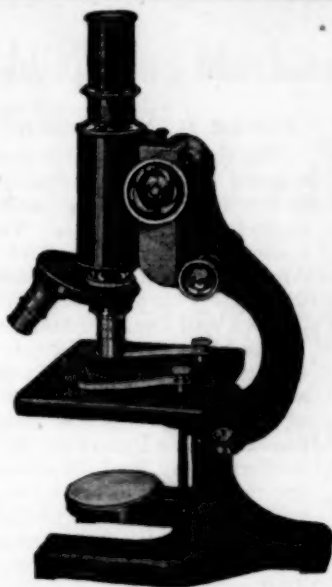
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ETHER MEASUREMENTS REVEAL PLANETARY MOTIONS.

The sun, and the solar system with it, is moving through space with a speed of over a hundred and thirty miles a second, towards a point in the direction of the constellation Draco, the Dragon, which partly encircles the north pole. This is one of the conclusions reached from recent experiments by Prof. Dayton C. Miller, of the Case School of Applied Science in Cleveland, and described by him in a recent radio talk given through station WCAP, under the auspices of Science Service and the National Research Council.

The experiments of Prof. Miller have been made at the Mt. Wilson Observatory in California since March, 1921, and involve the use of a delicate instrument called the interferometer and invented by one of Prof. Miller's predecessors, Dr. A. A. Michelson, now professor of physics at the University of Chicago. When the experiment was first performed by Prof. Michelson in 1887, an effort was made to detect the motion of the earth through the ether, which is supposed to pervade all space, and to be the medium through which light and similar forms of radiation are transmitted. However, though the apparatus was delicate enough to detect the expected motion, only a negligible drift was found, and one of the ultimate results of the effort to explain this anomaly was the Einstein theory of relativity.

In 1905, Prof. Miller, and the late Prof. Edward W. Morley, who collaborated in the original set of experiments, repeated them on a hill 200 feet high near Cleveland, and found a slight effect, but nothing further was done until 1921 when the present series was started at Mt. Wilson, more than a mile above sea level. These have resulted in what is interpreted as a marked drift of the ether and the explanation offered has been that under conditions such as those in Cleveland, and at sea level, the ether tends to be dragged along, but on a mountain top, there is nothing to obstruct it, and so it drifts by.

The general direction and amount of the drift has been determined by Prof. Miller by comparing measurements made at different times of the day and year. In the series of experiments which he conducted last year, Prof. Miller stated, over 100,000 readings of the instrument were made. "This required," he said, "that I should walk, in the dark, in a small circle, for a total distance of 100 miles, while making the readings."

The general motion of the earth, and the rest of the solar system, which Prof. Miller finds is in good agreement with measurements made by astronomers of the motion, and is towards a point in the sky having the right ascension, the celestial equivalent of longitude, of 262 degrees, and a declination, which corresponds to latitude, of 68 degrees north. Other determinations of the motion and its direction have been made by measurements of the motions of the stars in the sky, and of the star clusters. "These three determinations of the absolute motion of the system," said Dr. Miller, "are all in the same general direction and lie within a circle having a radius of 26 degrees. The assumed velocity of a hundred and thirty miles per second is about seven times the velocity of the earth in its orbit, and it is of a reasonable magnitude."

THE SCIENCE CLUB.

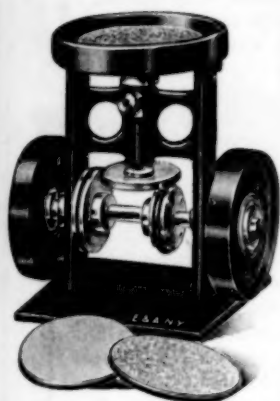
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the curriculum. In natural science the biology club may profitably be the outgrowth of the class work. As in all extra class activities it should originate from the students themselves but under the guidance of the teacher.

The science teacher through the club is able to guide the activities along definite lines so as to arouse and hold a vital interest in science, to lead the pupils to appreciate something of the general nature of the organic world about him, to arouse an interest in nature that will carry over into later life, to provide the pupil with a profitable way of employing his leisure time in recreational or even serious study of plants and animals under natural conditions, to guide the pupil into a scientific manner of thought that will tend to discourage false and superstitious beliefs of living things.

The teacher may by an original or ingenious manner stimulate a class or classes into the formation and organization of such a club. Here is one simple way of introducing it to the pupils. A clipping of the activities of the Biology club of another school may be posted on the bulletin board in a conspicuous place. When the teacher feels there is enough interest and enthusiasm aroused to warrant the launching of such an organization, then the first step may be taken. This may be in the form of an informal meeting of all students interested.

When the group meets for the first time, the teacher can present the important things to be done, such as appointing a committee to present the solution to some of the fundamentals of the club such as name, aims and purposes, membership, meetings, money, expelling members, business program, science program, officers, etc. Temporary officers may be elected. After a few meetings the organization can be completed and some well arranged meetings and programs presented. The time of the year will influence to a certain extent the nature of the programs and activities. Field trips may be a part of the activities; visits to museums and filtering plants; exhibits; talks by professional people; movies of scientific topics; assemblies; demonstrations and experiments by various pupils; etc. may form some of the programs.

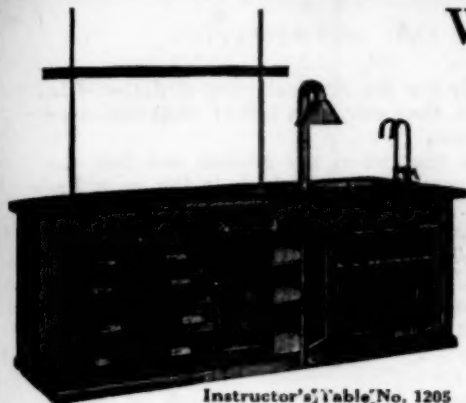
Among the helpful suggestions for the organization of a science club are those published in the *Monthly Guide for Science Teachers*¹, November, 1921. It deals with the General Science Club but it may be easily adapted to fit any of the sciences or modified in detail to meet the needs of any type of students or school. There are suggestions on the organization of the club, a sample program of a type activity, and method of procedure in organizing. In later issues other types of activities are described. The *Monthly Guide for Science Teachers* may be secured for three cents per copy from the publisher.

TRANSPLANTED PANCREAS CONTINUES TO FUNCTION.

A successful operation of transplanting a portion of the pancreas into the mammary gland of a dog has recently been performed by Drs. A. C. Ivy and J. I. Ferrell of the Northwestern University School of Medicine.

The pancreatic gland produces potent fluids necessary to the body, including insulin which prevents diabetes. The scientists do not believe, however, that this method of transplanting a portion of the

¹Monthly Guide for Science Teachers, Published by Popular Science Monthly, 225 West 39th Street, New York City, N. Y.



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pancreas can be used practically for the surgical cure of diabetes in man. It is merely another step, they say, to a better understanding of the physiology of the pancreas.

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It was also found that the transplanted piece of pancreas functioned to such an extent in producing a sufficient amount of insulin that diabetes would not occur when the remainder of the pancreas was removed.

BOOKS RECEIVED.

Standard Service Arithmetics, Book II for grades five and six by F. B. Knight and G. M. Ruch, College of Education, State University of Iowa and J. W. Studebaker, Superintendent of Schools, Des Moines. Pages xvii+547. 13.5x18.5 cm. Cloth. 1926. 96 cents. Scott, Foreman & Co., Chicago.

BOOK REVIEWS.

Bibliography of Science Teachers in the Secondary Schools by Earl R. Glenn and Josephine Walker of Lincoln School Teachers College, Columbia University, New York. Pages x+161. 15x23 cm. Paper. 1925. 20 cents. U. S. Department of the Interior, Educational Bulletin No. 13.

This pamphlet, without any question of a doubt, is the finest and most complete bibliography on Science teaching ever published. It surely is a most helpful aid to all Science teachers in the United States and Canada because all papers of any worth-whileness have been listed not only with the title but the author's name and the date and the source of publication have been given so it is easy for one desiring to read or study an article to secure the publication without any trouble.

This bulletin, without doubt, will assist wonderfully in spreading the gospel of good science teaching to all science teachers of this country, not only to the secondary school men but the university and college men will be interested in knowing where they can secure articles bearing upon the work which they are doing in their classes.

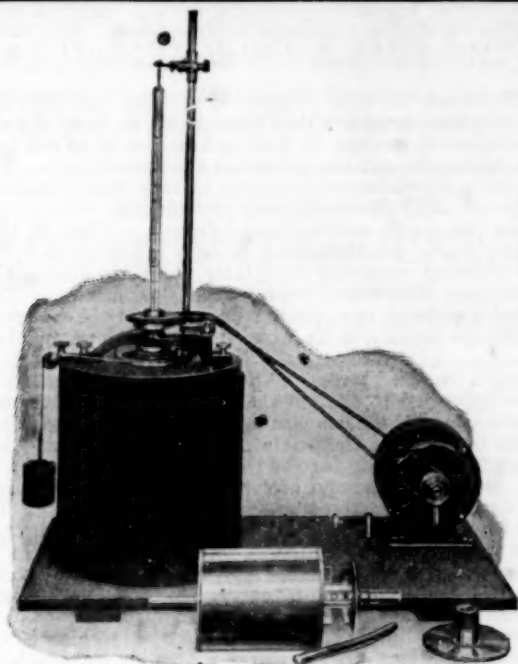
For the benefit of the readers of SCHOOL SCIENCE AND MATHEMATICS we would like to state that at least two-thirds of the names and articles that are mentioned in the book are articles from SCHOOL SCIENCE AND MATHEMATICS, which expresses, in some degree, the high appreciation with which this journal is held in the minds of science teachers.

C. H. Smith.

An Introduction to Earth History, by Hervey Woodburn Shimer, Ginn and Company, Boston. \$3.00.

Professor Shimer has rewritten the known facts about the history of the earth from a new point of view. He has written this new text book with the perspective of a physical geologist, but being mindful of the biologic history that has been a concomitant part of the evolving earth he devotes Part III to the History of the Life upon the Earth.

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